COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

November 1956

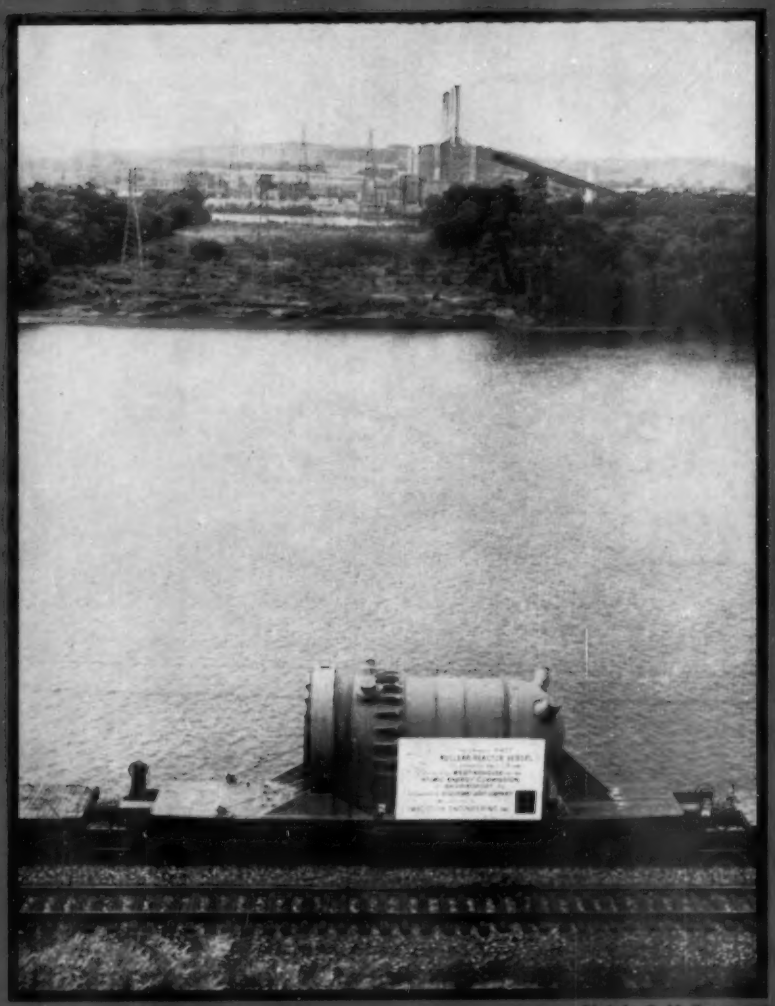


Photo by C. M. Zimmerman

Shell of 238-ton reactor vessel for Shippingport Power Station, world's heaviest unit of nuclear power equipment, passing world's largest anthracite-burning steam power plant, Sunbury Station of Pennsylvania Power & Light Co., en route from the Chattanooga plant of Combustion Engineering. See pp 48–49.

Fly Ash Refiring Experiences

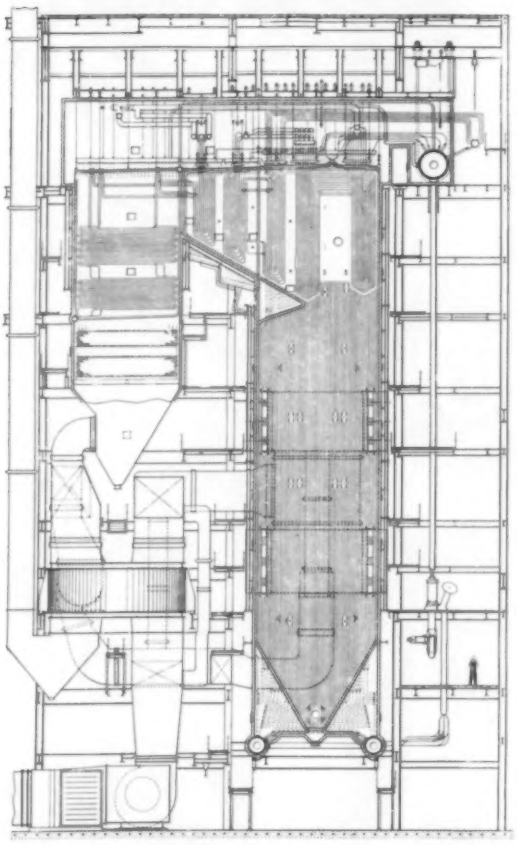
Power Trends and Boiler Feed Pumps—II

Quality Measurement by Flame Photometer

SCHUYLKILL STATION

Philadelphia Electric Company

C-E controlled circulation boilers



The C-E Unit shown above is presently under construction for the Schuylkill Station of the Philadelphia Electric Company, Philadelphia, Pa.

The boiler is designed to serve a 175,000 kw turbine-generator operating at a throttle pressure of 2400 psig with a primary steam temperature of 1050 F, reheated to 1000 F.

It is of the controlled-circulation, radiant reheat type with a separated furnace arrangement. Secondary superheater surface is at the outlet of one furnace and reheater surface at the outlet of the other. Primary superheater sections and economizer surface follow both the secondary superheater and reheater surfaces. Regenerative air heaters follow the economizer surfaces. The section shown above is taken through the superheater furnace.

The unit is oil fired and uses tilting, tangential burners. It is arranged for future use of coal and/or gas as required. B-960

C-E

COMBUSTION ENGINEERING, INC.

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

STEAM GENERATING UNITS; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; HOME HEATING AND COOLING UNITS; DOMESTIC WATER HEATERS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 28 **No. 5**

November 1956

Feature Articles

Fly Ash Refiring.....*by Wallace W. Maull and Earl C. McMahon* 40

PWR Vessel En Route from Chattanooga to Shippingport..... 48

Steam Power Plant Trends and Their Effect on the Boiler Feed Pump—II.....*by I. J. Karassik* 51

Quality Measurements by Flame Photometer.....*by J. K. Rice* 57

Seventeenth Annual Water Conference..... 63

Atomic Industrial Forum..... 69

Editorials

A Hopeful View of the Atom..... 39

Feeding the Thirst for Knowledge 39

Departments

Advertising Index.....82, 83

COMBUSTION published its annual index in the June issue and is indexed regularly by Engineering Index, Inc.

The magazine is now reproduced and distributed to libraries on microfilm by University Microfilms of Ann Arbor, Michigan.

GERALD S. CARRICK
Business Manager

JOSEPH C. McCABE
Editor

GLENN R. FRYLING
Associate Editor

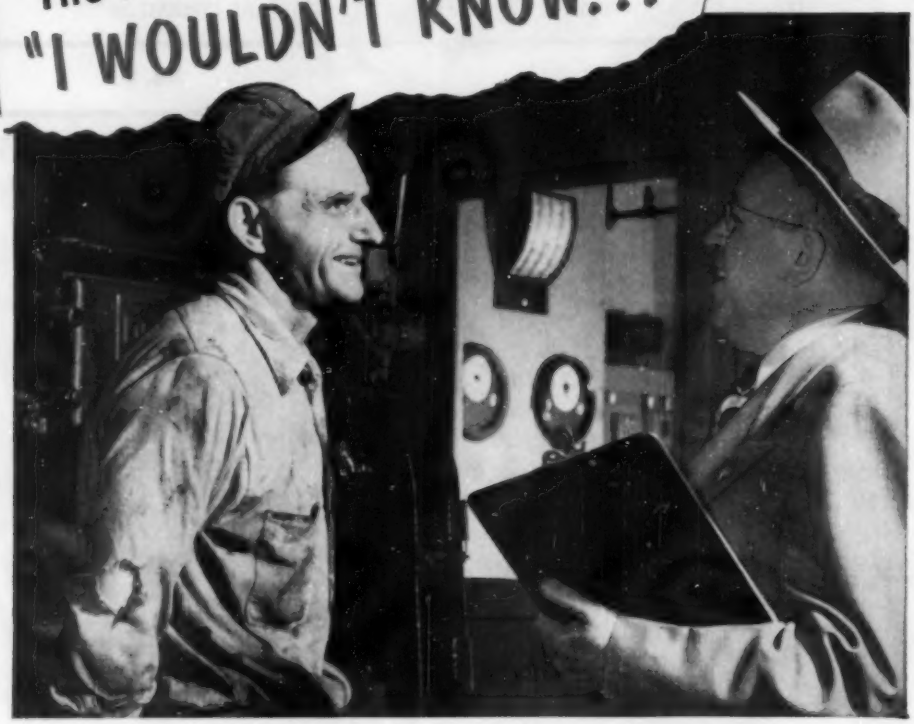
CARL G. UDELL
Circulation Manager

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING, INC.
Joseph V. Santry, Pres.; Charles McDonough, Vice-Pres.; Otto Strauss, Treas.; Thomas A. Ennis, Secy.
COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $4 in the United States, $5.50 in Canada; and $8 in Latin America and other countries. Single copies: Domestic, 40 cents: Foreign, 60 cents plus postage. Copyright 1956 by Combustion Publishing Company, Inc. Publication Office, Easton, Pa. Issued the middle of the month of publication.
Acceptance under Section 34.64, P.L. & R., authorized by United States Post Office.

BPA

Printed in U. S. A.

The Power Plant Engineer Said: "I WOULDN'T KNOW..."



INQUIRING REPORTER: So you use Nalco System water treatment ... How often are your boilers turbined?

ENGINEER: I wouldn't know—only worked here seven years. *

You recognize the Engineer's answer as a twist on the old one about *How-often-do-you-get-a-raise-around-here.* Our excuse for bringing it up is that the engineer's answer applies to hundreds of plants using Nalco water treatment. New plants, starting boilers from scratch with Nalco, report years on line, *billions* of pounds of steam generated in boilers that have *never* been turbined ... and probably never will be. Older plants, where turbining was as routine as checking the draft gauges, now open boilers only to show the inspectors.

These Nalco *results* can quite possibly be duplicated in your plant, regardless of the kind or severity of your water treatment problems ... or the size of your operation. Write or phone, now, for a fast start toward permanent water treatment security.

NATIONAL ALUMINATE CORPORATION

6234 West 66th Place • Chicago 38, Illinois

Telephone: POrtsmouth 7-7240

In Canada: Alchem Limited, Burlington, Ontario

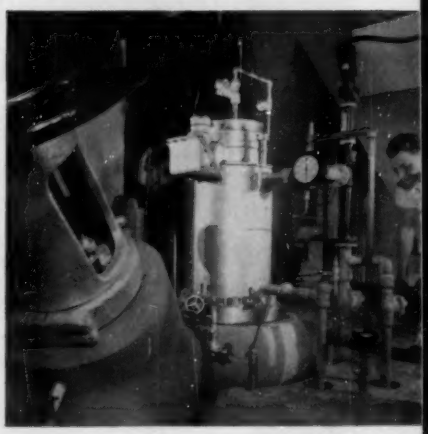
THE *Nalco*® SYSTEM ... Serving Industry through Practical Applied Science

Westinghouse "canned" pump eliminates leakage at VEPCO

Zero leakage! No injection water sealing required. Pump may be kept on hot or cold stand-by. No seal maintenance. Windings protected by nickel "cans" welded in place. No bearing lubrication.

These are advantages realized by Virginia Electric Power Company with the installation of a Westinghouse "canned" motor pump in the controlled circulation boiler system of the new Possum Point Station.

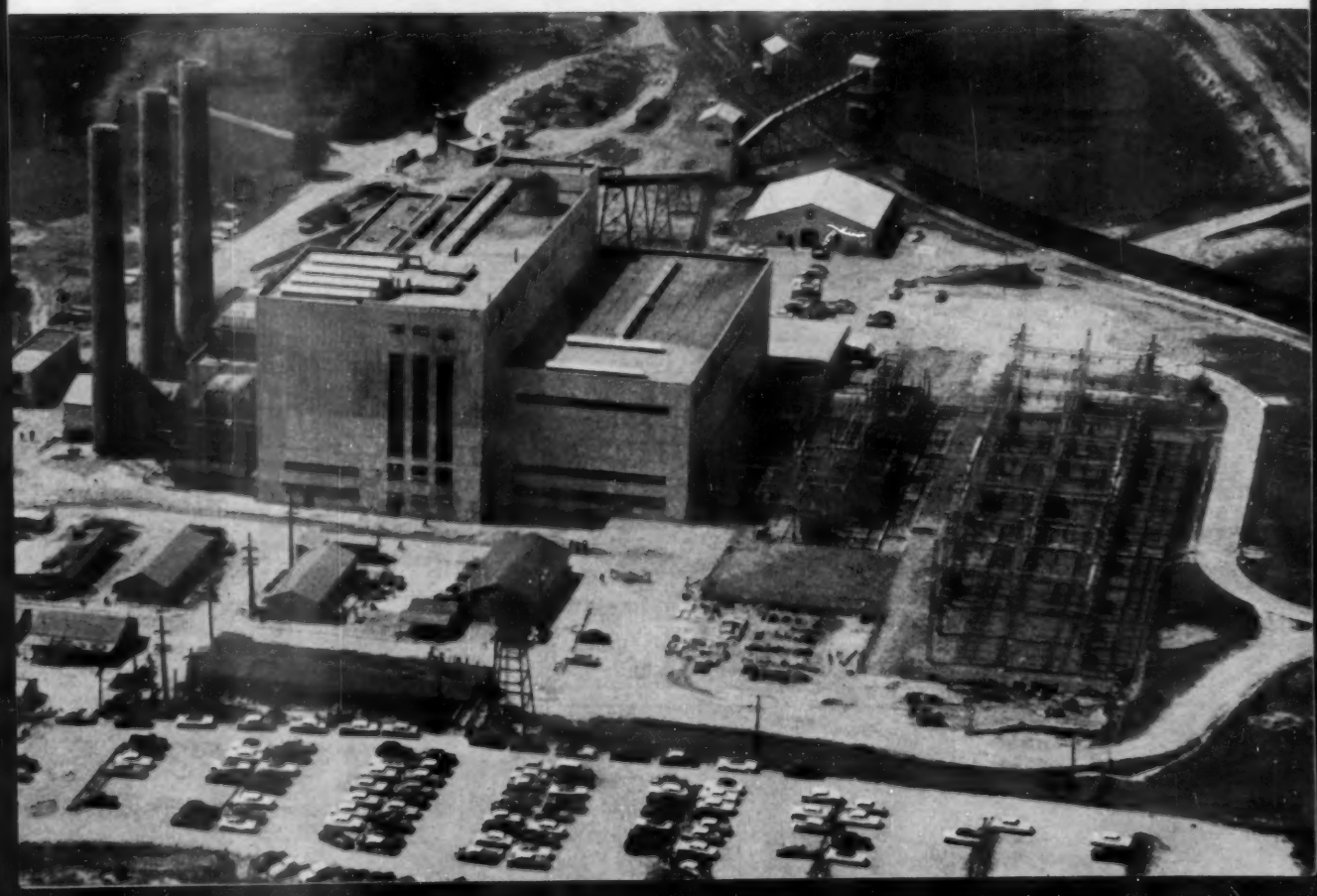
VEPCO, Stone & Webster and Combustion Engineering pioneered the power station application of this pump which was first developed to handle radioactive fluids in nuclear reactor loops. All the development work is now complete and the installation has been in actual service at Possum Point for over a year. J-57005-X



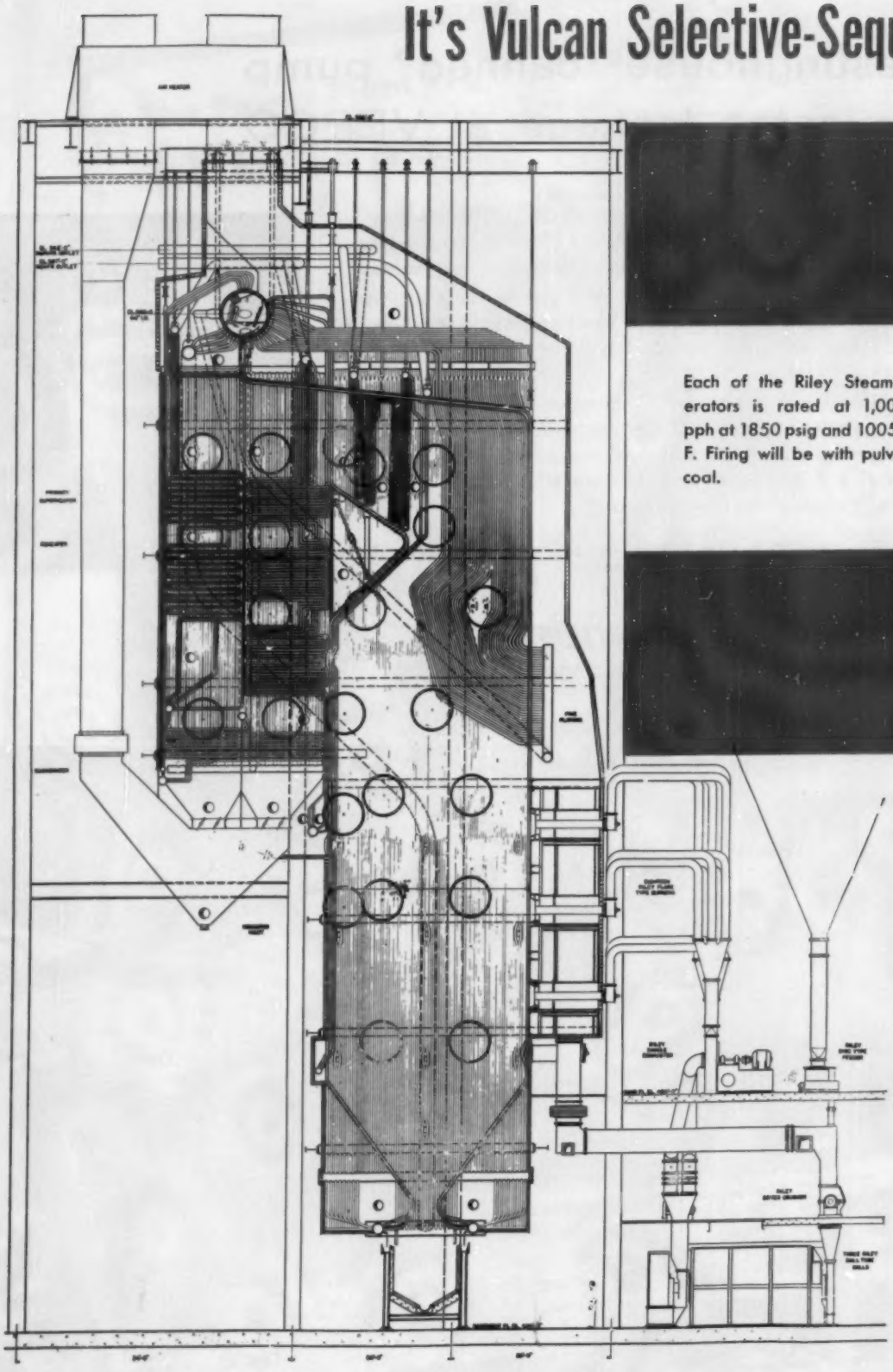
Westinghouse "canned" pump in Combustion Engineering controlled circulation boiler at Virginia Electric's Possum Point Station.

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***

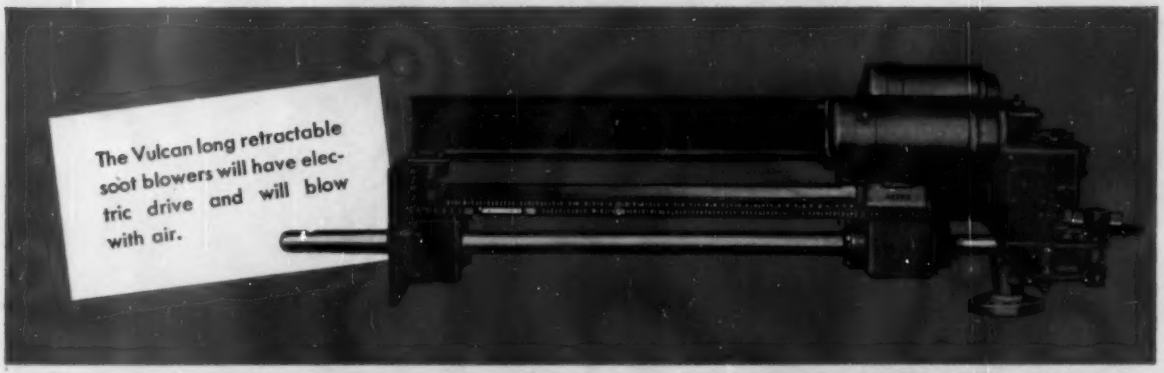


It's Vulcan Selective-Sequence



Each of the Riley Steam Generators is rated at 1,000,000 pph at 1850 psig and 1005/1005 F. Firing will be with pulverized coal.

at New Albany Generating Station



Boiler cleaning systems for Units 1 and 2 in the New Albany Station of Public Service Company of Indiana will be under Vulcan Selective-Sequence Control. Each of the two Riley Steam Generators will be equipped with a Vulcan Soot Blowing System which includes Long Retracts and Wall Deslaggers.

Selective-Sequence operation of the soot blowing system was chosen to give positive operation at proper intervals in precisely the sequence necessary for the most effective cleaning. Vulcan Long Retractable Soot Blowers with two motor operation assure maximum coverage with uniform cleaning of all surfaces. Vulcan Wall Deslaggers deliver maximum striking power to drive off slag, assuring high heat-transfer capacity and uniform control of superheat and reheat temperatures.

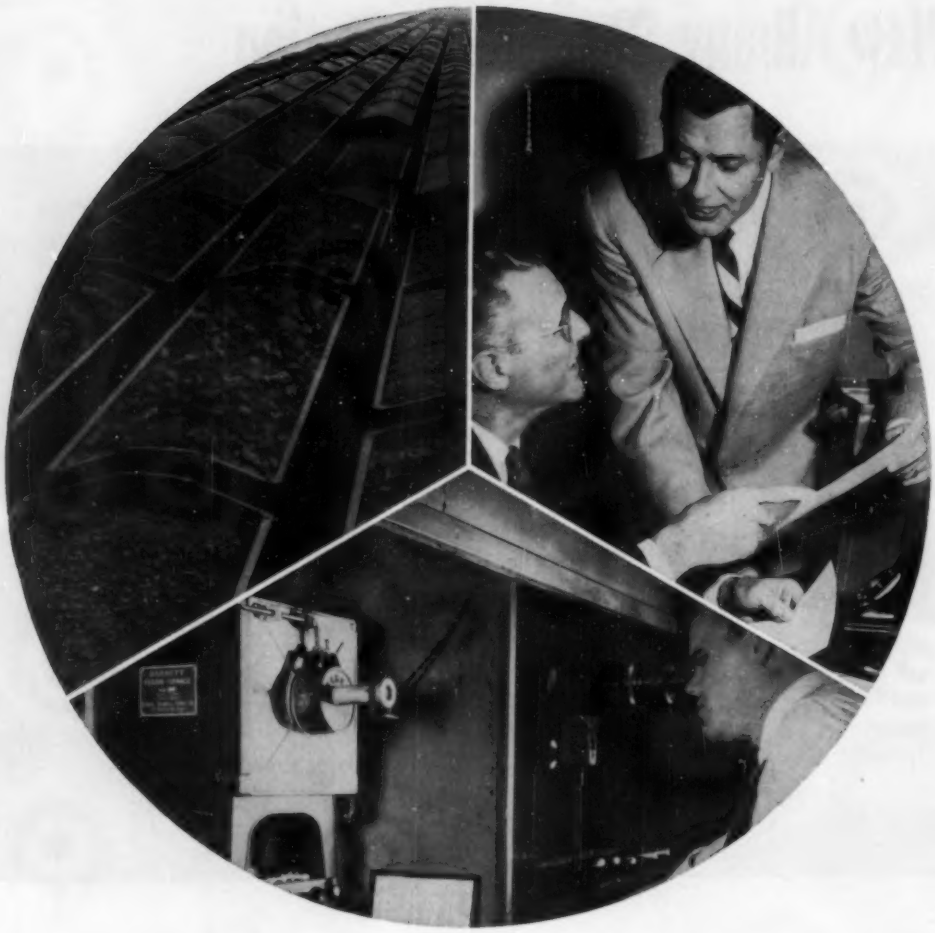
Modern soot blowing systems, with either automatic-sequential or selective-sequence control, can help keep your boilers operating at peak efficiency. Whether your boiler is power or process, large or small, investigate Vulcan Automatic Soot Blowing Systems for better cleaning results.

COPES-VULCAN DIVISION

BLAW-KNOX COMPANY

ERIE 4, PENNSYLVANIA

50th Anniversary BLAW-KNOX 1906-1956



BEACON COALS FOR ELECTRIC UTILITIES,

Industrial and Commercial Uses

Here are some facts that may interest you — as a buyer of coal for power plant use — when you are seeking a dependable source of supply.

Our yearly productive capacity is in excess of 10,000,000 tons. We can meet tonnage requirements of the largest user, and adhere to the strictest time-table on shipments.

We produce, in our fifteen active mines, a variety of coals with a complete range of analyses. We can thus satisfy the most exacting specifications . . . and furnish the fuel best suited to your particular combustion equipment.

We maintain a central coal laboratory, supplemented by quality control labs at each of our larger mines. This assures conformity to standards.

Our representatives are trained combustion men, who can understand your needs, and work intelligently to meet them. Inquiries and follow-ups are expedited by our teletype network, which connects sales offices with all our major mines.

Doesn't it seem reasonable to think that our *product* plus our *service* can bring you something extra in filling your fuel needs? We'd like to demonstrate that it can.

EASTERN GAS AND FUEL ASSOCIATES
BEACON COAL

EASTERN GAS AND FUEL ASSOCIATES

Pittsburgh • Boston • Cleveland • Detroit • New York
Norfolk • Philadelphia • Syracuse

For New England: NEW ENGLAND COAL & COKE CO.

For Export: CASTNER, CURRAN & BULLITT, INC.

47 miles of Johns-Manville 85% Magnesia Insulation boosts operating efficiency of Plant Hammond, one of the South's largest and most modern private utility installations.

Insulating feed water line at Plant Hammond. Contractor for this job was Brooks-Fisher Insulating Company of Atlanta, Georgia.

J-M 85% Magnesia Insulation helps cut fuel rate 25% below national average

Officials of the Georgia Power Company were gratified when the coal rate of their new Plant Hammond worked out at 0.75 lb. per KW HR, 25% below the national average. In their annual *Electrical Industry Statistics, Electrical World* had reported that increased efficiency in the techniques of power production has lowered the average coal rate to 1 lb. per KW HR. in 1954.

An important factor contributing to Plant Hammond's high efficiency was the selection of insulation. Johns-Manville's 85% Magnesia was applied in the most economical thicknesses throughout the plant for all piping and equipment operating in its temperature range. At higher temperatures 85% Magnesia was used in combination with J-M Superex® diatomaceous silica insulation.

This is only one of thousands of case histories where J-M 85% Magnesia has helped industry achieve outstanding fuel savings and increased operating efficiency. In all types of manufacturing and processing plants it is the standard for temperatures to 600F . . . providing high insulating value, easy application, long life, initial low cost and minimum maintenance. Write today for further information on J-M 85% Magnesia and Johns-Manville's complete drawing-board-to-job-site insulation service. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JM PRODUCTS

Johns-Manville *first-in* INSULATION

MATERIALS · ENGINEERING · APPLICATION

NEW! "BUFFALO"

a new high

MOST STREAMLINED INLET — note smooth inlet bell matching the deep drawn wheel flange to form a "true half circle" inlet into wheel.

DEEPER BLADES FOR DEEPER "BITE" — note exceptionally deep blade design in photo below. This improves air flow thru blade channels. Flanged hubs—smoothly curved for best air entry conditions.

The wheel has been dynamically tested in the "Buffalo" Vacuum Pit — possible only at "Buffalo". By spinning various rotor designs to destruction the optimum wheel construction was determined — another "Buffalo" "Q" factor.*

"Buffalo" Air Foil Wheel. Note "deep-bite" blades for most efficient air handling.

***The "Q" Factor — the*

BUFFALO

BUFFALO,

Canadian Blower &

VENTILATING AIR CLEANING AIR TEMPERING PRESSURE BLOWING

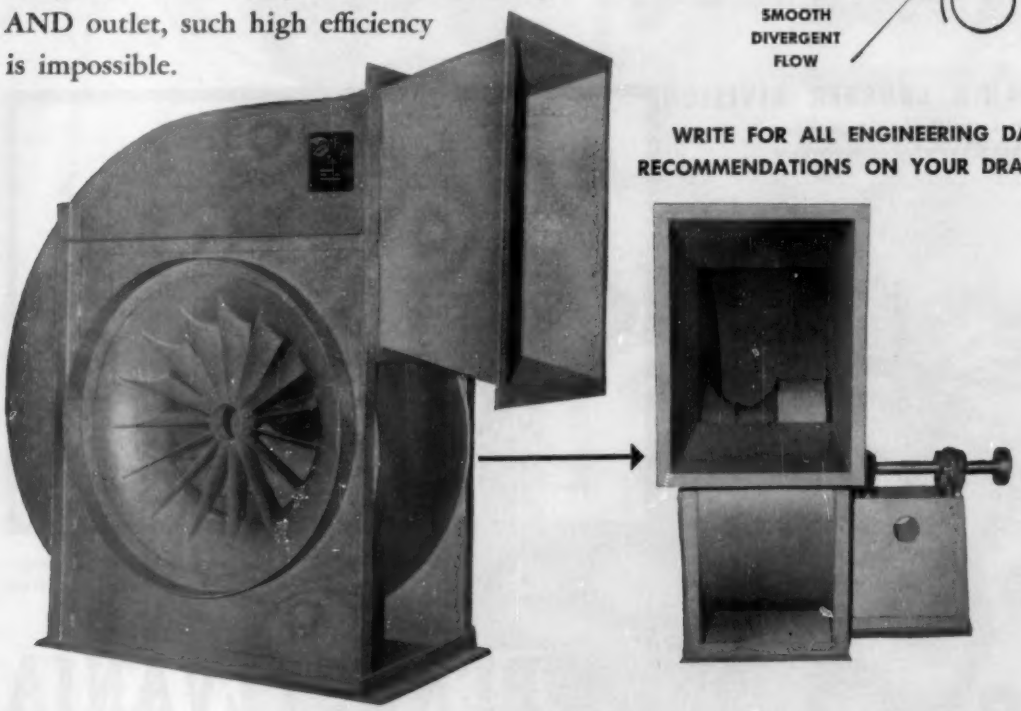
"Deep Blade" AIR FOIL FANS

in forced draft performance

IMPROVED FAN OUTLET — reduces outlet air turbulence from fan cutoff into duct by making more even, gradual change from velocity to static pressure. Without this complete streamlining of inlet, housing AND outlet, such high efficiency is impossible.

92% MECHANICAL EFFICIENCY — not an inflated claim, but proved performance you can expect in field operation.

WRITE FOR ALL ENGINEERING DATA AND RECOMMENDATIONS ON YOUR DRAFT PROBLEM



built-in Quality which provides trouble-free satisfaction and long life.

FORGE COMPANY

"Buffalo"

NEW YORK

Forge Co., Ltd., Kitchener, Ont.

INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING

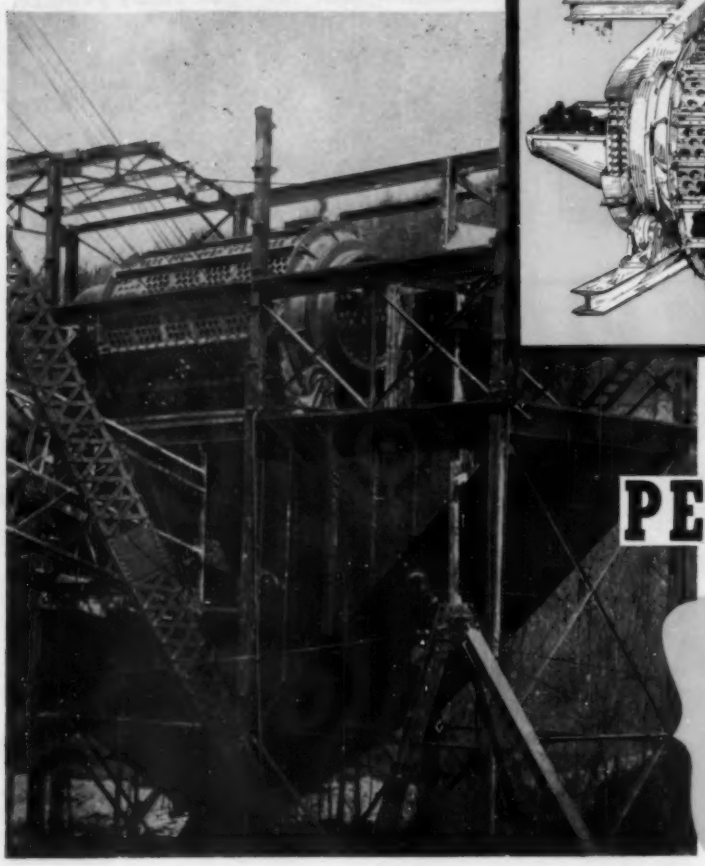
The economical way to size and condition ROM coal

The time proved Pennsylvania Bradford Breaker is the only crusher that mechanically scavenges hard refuse. It greatly reduces the refuse load handled by the cleaning plant and protects other equipment from damage by large mine debris.

The gravity impact method of reduction is a most efficient means of reclaiming "bony" coal and coals with attached impurities. Passing sizes are immediately screened out through the Bradford screen plates, but the larger lumps are raised on the radial lifting shelves and dropped, breaking into passing sizes and separating from the clinging impurities at the lines of cleavage.

An analysis of ten complete installation records, covering an average of 8.6 years of operation per Breaker, shows maintenance costs averaging under $.001 per ton and power consumption .274 HP per ton. Figures like these are what operators are looking for in this day of mounting operating costs. Call on us for complete information and counsel.

PENNSYLVANIA CRUSHER DIVISION
Bath Iron Works Corporation
West Chester, Pennsylvania



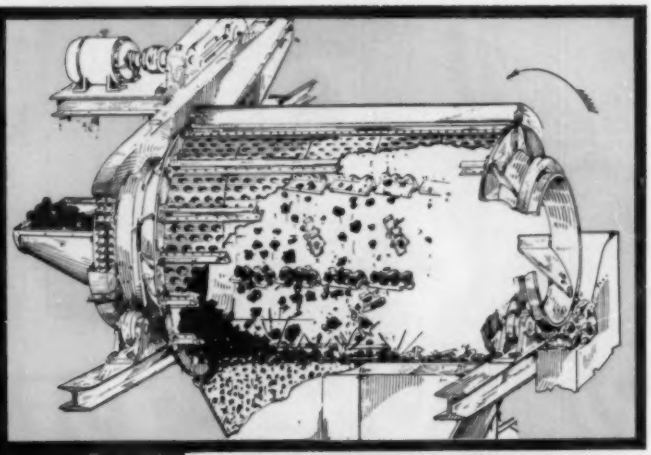


Illustration at left shows a roller mounted Pennsylvania Bradford Breaker being assembled at a West Virginia cleaning plant.

PENNSYLVANIA

BRADFORD BREAKERS

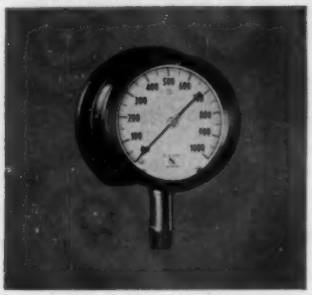
PE-215

Why does the BOURDON TUBE in the ASHCROFT DURAGAUGE insure sustained accuracy?

FOR FAST SERVICE, get in touch with your Industrial Supply Distributor. He is fully acquainted with Ashcroft Duragauges and their proper selection for all kinds of applications.

8 TUBE MATERIALS permit selection of the *best metal* for particular service conditions. These materials include phosphor bronze, alloy steels, "K" Monel, stainless steels, and beryllium copper.

Every Bourdon tube used in the Ashcroft Duragauge is extra-wide – highly sensitive to slight pressure changes. Socket and tip joints are welded or brazed, then stress relieved after assembly, to assure maximum safety and uniform structure for highest corrosion resistance and strength. Each tube assembly is "whip tested" at pulsating pressures approximately 50% higher than its pressure rating to insure calibration stability.



The Ashcroft Duragauge is available with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. A choice of case designs and materials, dial sizes and pressure ranges readily satisfy the most exacting requirements. Whatever the working pressures or corrosive conditions of your operations, specify Ashcroft Duragauges and be sure of highest sustained accuracy and long service life.

1850 ASHCROFT U.S.A.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

NOW... you can obtain the advantages of the I-R UNIT-TYPE

Here's how the I-R Unit-Type rotor design contributes to dependable pump performance with minimum operating and maintenance expense.

HIGH EFFICIENCY— throughout years of operation

The simplicity of Unit-Type rotor design with precision-matched impellers and channel ring sections plus simple, direct fluid passages results in high operating efficiency. Efficiency stays high, too, because clearances are realistic and can be maintained without frequent replacement of wearing parts.

EASIER MAINTENANCE— and less of it

The Unit-Type rotor permits quick and easy removal of the entire rotor assembly without disturbing suction and discharge connections. All parts of the assembly are readily accessible, and easy to remove and reassemble. There are no shrink fits or delicate alignment problems.

GREATER INTERCHANGEABILITY— smaller spare parts inventory

Maximum interchangeability of rotor-assembly parts makes it unnecessary to stock separate replacement units for each individual stage. Except for the suction and discharge stages, impellers and channel rings are completely interchangeable.

SYMMETRICAL CASING— for greater strength

Unit-Type rotor assembly eliminates intricate hydraulic passages in the casing. The symmetrical casing provides greater strength, minimizes thermal distortion, and permits an attractive, streamlined exterior appearance.

FLEXIBILITY OF DESIGN— permits changes in operating conditions

Changes in operating conditions can be met easily by installing a new combination of impellers and channel rings on the original shaft...in the original casing. Forseeable changes in operating conditions can also be met by using "dummy" stages which can later be replaced by complete working assemblies. Unit-Type rotor design and smooth bore casing makes this possible.

FOR FURTHER INFORMATION— see your nearest I-R representative

Your local I-R Sales Engineer will welcome the opportunity to work with you in the selection of boiler-feed pumps best suited to your requirements. Ask him to tell you about the latest advances Ingersoll-Rand has made in pumps for condenser circulating, condensate, heater drip and other power plant and central station services.

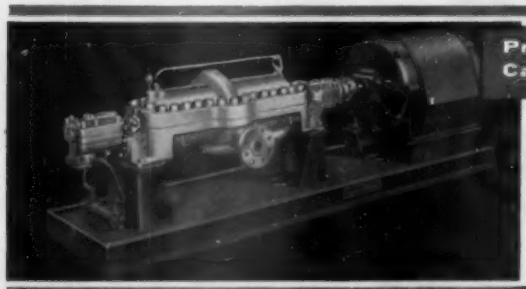
Ingersoll-Rand

10—440

11 Broadway, New York 4, N. Y.

ROTOR ASSEMBLY

in a complete line of boiler-feed pumps for pressures from 300 to 6500 psi

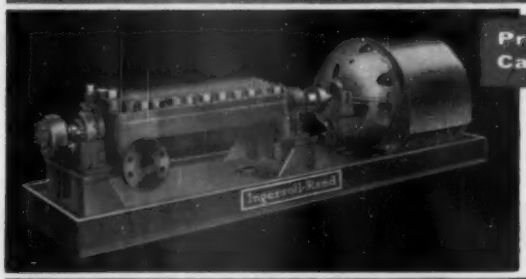


Pressures: 300 to 1000 psi
Capacities: to 700 gpm

Class CNTA

Recommended for medium pressure installations, the Ingersoll-Rand Class CNTA is today's most modern and efficient multi-stage boiler-feed pump in its pressure class.

It has a smooth-bore, symmetrical casing and features opposed impeller groups to neutralize axial thrust. Bearings can be either sleeve- or ball-type.

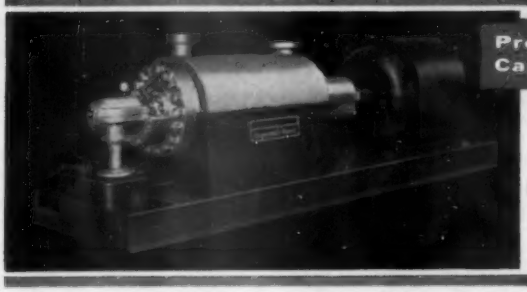


Pressures: to 1200 psi
Capacities: to 1600 gpm

Class HMTA and HMTB

I-R Class HMTA and HMTB multi-stage centrifugal pumps feature a symmetrical, horizontally-split casing and "in-line" staging.

Supplied in from 3 to 9 stages, they are widely installed as boiler-feed pumps in central stations and industrial plants. Ball- or sleeve-type bearings are available.



Pressures: to 6500 psi
Capacities: to 2800 gpm

Class CHTA and CHTB

Of the double-case design, Class CHTA and CHTB multi-stage centrifugals consist of a vertically-split inner assembly enclosed in a heavy cylindrical outer casing.

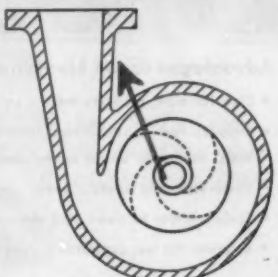
More of these Ingersoll-Rand pumps are installed in high-pressure boiler-feed service than any other make—indisputable proof of their overwhelming acceptance by modern central stations.

Thrust forces balanced with multiple-volute design

COMPLETE RADIAL BALANCE—a feature of all these I-R boiler-feed pumps

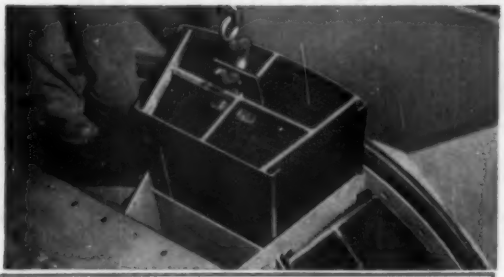
Evenly spaced volute passages around the entire circumference of the impeller balance the radial thrust force. That is, the radial forces become equal in all directions with a zero resultant on the impeller.

With a single volute casing, a radial thrust force is created due to the uneven pressure distribution around the periphery of the impeller. This force tends to deflect the shaft and cause the rings to rub with a loss in efficiency.



Thrust on impeller unbalanced in single volute design

air preheater installations are Ljungstrom®



Advantages of the Ljungstrom Air Preheater

- Size for size, recovers more heat than any other type.
- Reduces fuel consumption. Permits use of lower-grade fuels. Increases boiler output and reliability.
- Eliminates cold spots...keeps corrosion to a minimum.
- Easier, faster to clean and maintain.
- Requires far less supporting steel and is quickly erected.

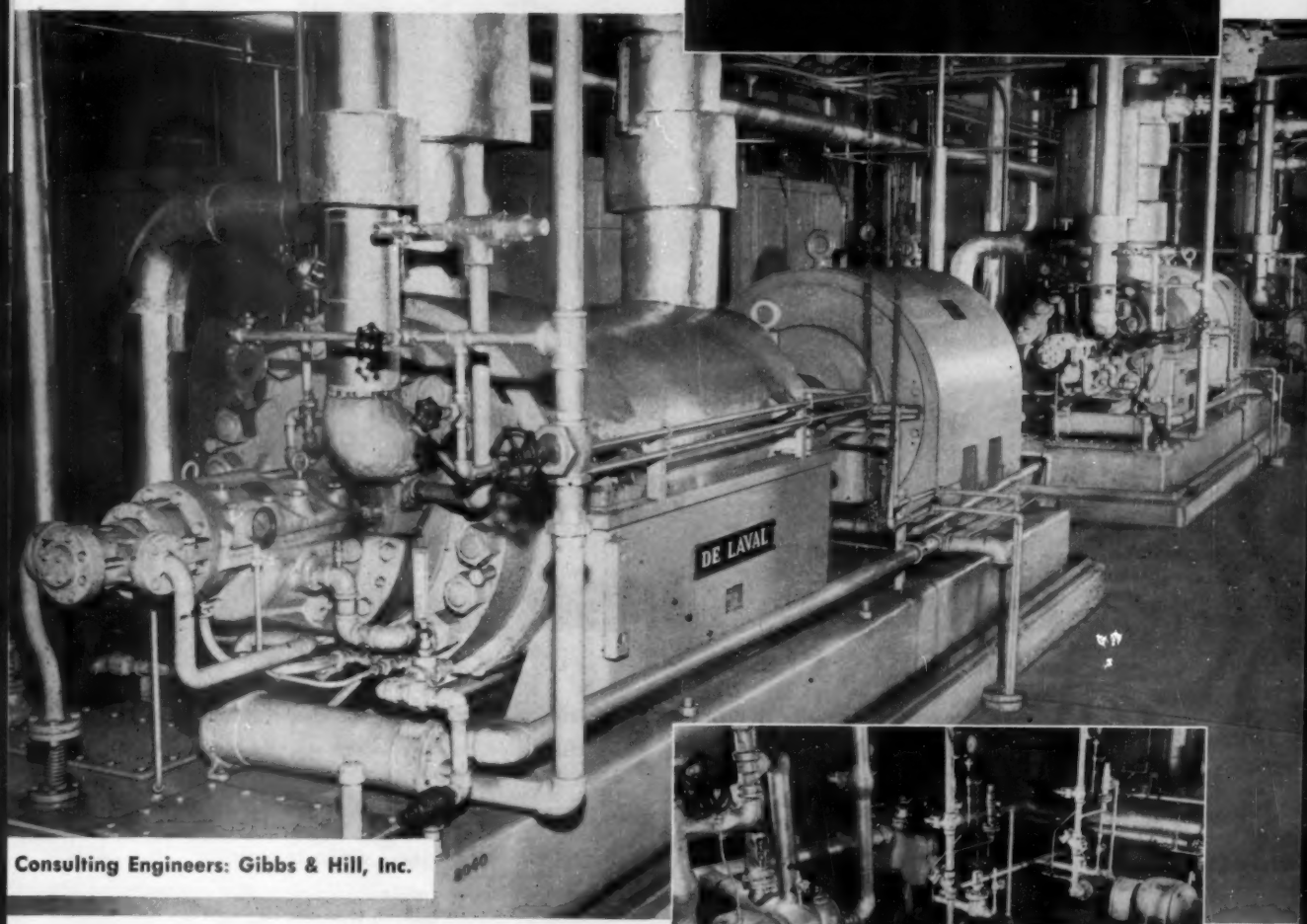
MINIMUM CORROSION is an important reason. There are no cold spots in a Ljungstrom. Temperature is uniform on all heating surfaces—corrosion-causing condensation is reduced.

For all the facts, send now for a free copy of our 38-page manual.

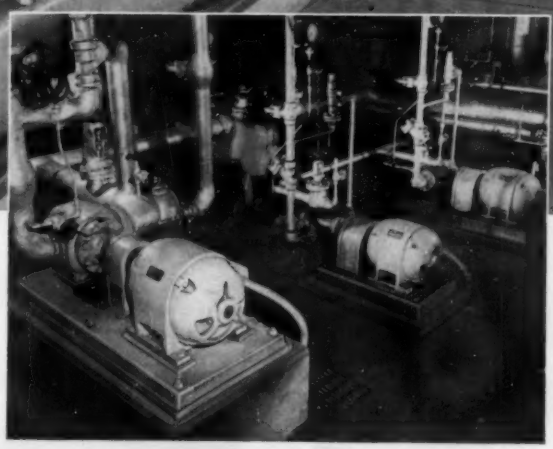
The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

Atlantic City Electric ... another utility using

DE LAVAL
BARREL TYPE BOILER FEED PUMPS



Consulting Engineers: Gibbs & Hill, Inc.



De Laval IMO rotary positive displacement pumps handle heavy fuel oil. They are used for standby operation.

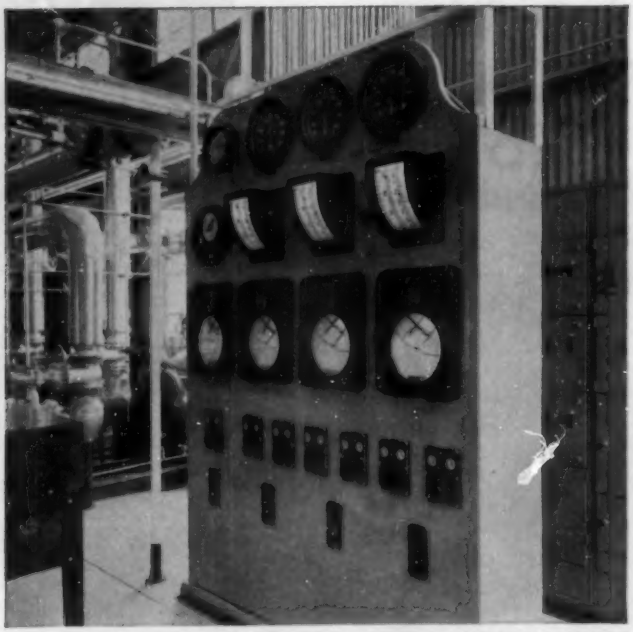
Atlantic City Electric Co. and Gibbs & Hill, Inc., Consulting Engineers, know that they can count on De Laval reliability. That's why they selected three De Laval high pressure barrel type boiler feed pumps for the Deepwater Station in Penns Grove, New Jersey. These 10-stage units deliver 675 gpm, operating at 1762 psi with temperature at 287 F. The pumps are driven by 900 hp motors.

De Laval barrel type boiler feed pumps operate at pressures up to 5500 psi. These units offer many important design advantages, such as double volute diaphragm, individual diaphragm bolting, only one inner high-pressure joint, and bare shaft construction. Their dependability is proven by year in, year out service in public utilities and industrial plants.

Send for De Laval Bulletin 1506, which contains helpful data.

DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY
886 Nottingham Way, Trenton 2, New Jersey



Bailey Boiler Control Panel for three 150,000 lb per hr, 400 psi, gas-fired boilers. Meter at left records total Steam Flow; the other three meters record Gas Flow—Air Flow and Flue Gas Temperature.

How to Control Steam Costs

★ Close regulation of fuel and air input is vital to a strict control of your steam cost. But that's not all. You'll need control of other factors, too. Your costs can be held down only by controlling all of the important operations in your steam plant. That's where you can be sure of help from Bailey Controls. Here's why they can do the job and do it right:

1. Suitable Equipment

When you receive equipment recommendations from a Bailey Engineer his selections come from a complete line of well-engineered and carefully tested products.

2. Seasoned Engineering Experience

Your local Bailey Engineer brings you seasoned engineering experience based on thousands of successful installations involving problems in measurement, combustion, and automatic control.

3. Direct Sales-Service—close to you

For your convenience and to save time and travel expense there's a Bailey District Office or Resident Engineer in or close to your industrial community.

For greater fuel savings, less outage and safer working conditions, you owe it to yourself to investigate Bailey Controls. Ask a Bailey Engineer to arrange a visit to a nearby Bailey installation. We're glad to stand on our record. A-125-1

FORMULA
for Cutting
Steam Costs
•
+ Bailey Design
+ Bailey Engineering
+ Bailey Service
= Greater Savings
per Fuel Dollar

BAILEY
METER COMPANY
1025 IVANHOE ROAD
CLEVELAND 10, OHIO
Complete Controls for Steam Plants

BAILEY METERS
Controls for
COMBUSTION
FEED WATER
TEMPERATURE
PRESSURE
LIQUID LEVEL
FEED PUMPS

Move 15 tons at a pass . . .

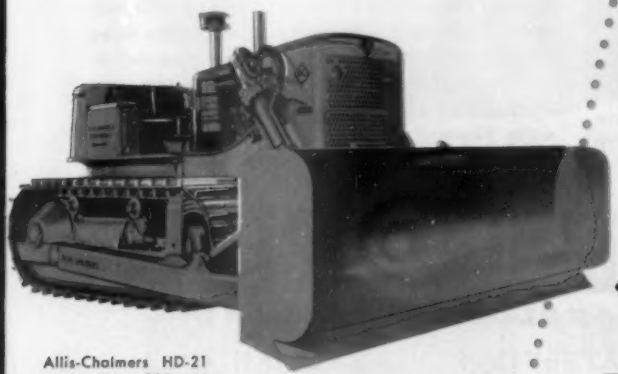
using Allis-Chalmers HD-21 Tractor with special coal blade

A special coal-handling blade now available for the Allis-Chalmers HD-21 fully uses the tremendous power and weight of this big tractor to move 15 tons of coal at a time.

HD-21 is coal-handling specialist— With its 204-hp diesel engine, the HD-21 has plenty of power for moving big loads. The hydraulic torque converter drive multiplies drawbar pull up to four and a half times, automatically accelerates to the highest traveling speed conditions permit. The torque converter permits climbing steeper grades, prevents killing the engine or digging in at soft spots, eliminates effort and time lost in shifting.

The compacting effect of a crawler tractor is well known. Through repeated trips over the coal pile, the 26-ton HD-21 and blade eliminate voids, prevent spontaneous combustion. The blade is shaped to move coal easily with a minimum of coal separation.

Dependability of the HD-21 is assured by Allis-Chalmers advanced design — Box-A Type Main Frame, one-piece steering clutch and final drive housing, straddle-mounted final drive gears, roller bearing truck wheels, through-hardened track rails — which also mean long life, less maintenance and faster repair when necessary.

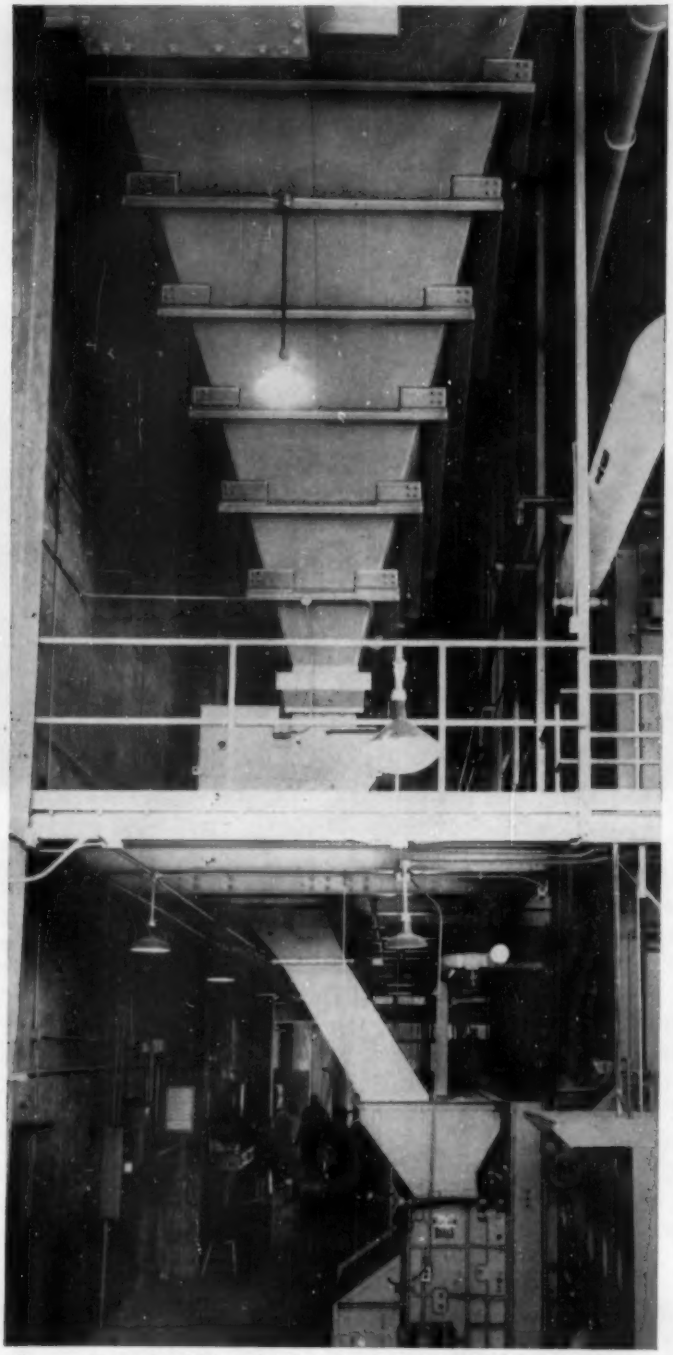


Allis-Chalmers HD-21 tractor has 204 net engine hp, weighs 26 tons complete with cable or hydraulically controlled blade. Special coal blade has extra 56½-in. height and 15-ft length, plus boxed-in ends to carry 15 tons or more at a pass.

For additional information about the HD-21 tractor and coal blade — or about the other Allis-Chalmers tractors, tractor shovels, scrapers and motor scrapers — see your Allis-Chalmers construction machinery dealer or write direct to the company.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION
MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS



One more new installation of Lukens Type 304 *stainless-clad* steel — these smooth-operating coal hoppers and chutes, fabricated by Fairfield Engineering Company, Marion, Ohio, feed through second-floor scales to boiler.

Clad Steel Chosen Again...

STEADY COAL FLOW A MUST IN NEW STATE HOSPITAL PLANT!

Hospitals can't take a chance on power interruptions from coal hangups. In Wisconsin's Mendota State Hospital, three *stainless-clad* steel coal hoppers and chutes, three-stories high, assure smooth, dependable coal flow. In more and more coal handling installations, clad steel is being specified because of these *demonstrated* advantages:

- Substantial economies from lower maintenance costs in chutes, hoppers, bunkers, pipes and spreaders.
- Freedom from hangups and the damaging and costly effects of sulfuric acid corrosion from wet coal.
- Toughness proved by *installations 10 years old which showed no measurable wear!*
- Evidence of service life that matches the life of the boiler!

PLUS: ready fabrication . . . permanence of bond between stainless steel cladding and strong, low-cost carbon steel backing . . . over-all quality that delivers lower maintenance costs, longer life, and trouble-free operation.

Bulletin 740 will give you performance facts and product information to help your engineers make the most of clad steel. For this bulletin, as well as the names of some of the nation's best and most experienced coal handling equipment builders, write Manager, Marketing Service, 845 Lukens Building, Lukens Steel Company, Coatesville, Pa.

STAINLESS-CLAD STEELS

LUKENS

FOR INTERIOR COAL HANDLING EQUIPMENT

LUKENS STEEL COMPANY, COATESVILLE, PENNSYLVANIA

Producers of the Widest Range of Types and Sizes of Clad Steel Available Anywhere

this is "life insurance" for boilers

It's a good "policy" to protect your valuable boilers with YARWAY Boiler Level Indicators.

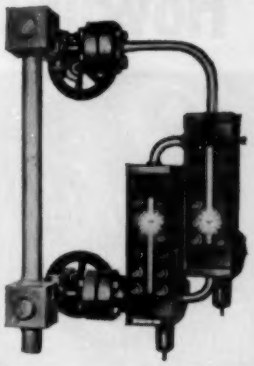
Instant . . . accurate . . . continuous remote readings of boiler water levels are available on the instrument panel or wherever you wish in the plant.

YARWAY's new "wide vision" face gives brilliant readings from any angle . . . and the pointer is always visible, even at extreme high and low water levels.

For brilliant "shines like a star" readings on the boiler drum you'll want to use YARWAY Flat Glass Gages with Type "M" Illuminators.

From drum to panel and at all remote locations, YARWAY equipment gives you the safest boiler protection you can buy—proved beyond doubt in nearly 10,000 installations.

Yarway Remote Liquid Level Indicator. Write for Yarway Bulletin WG-1824.



Yarway Flat Glass Water Gage with Type "M" Illuminators. Write for Yarway Bulletin WG-1812.

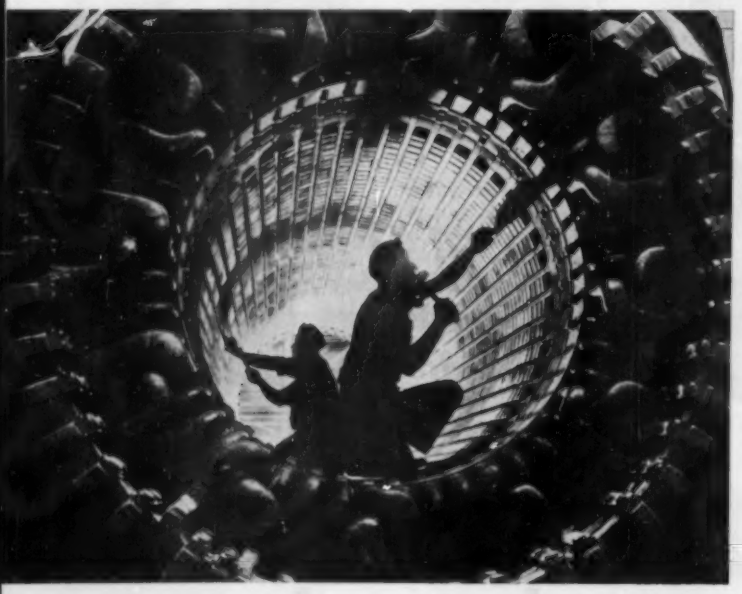
YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

SEE THE YARWAY EXHIBIT IN BOOTH 532
AT POWER SHOW IN NEW YORK COLISEUM
NOVEMBER 26–30

YARWAY **steam plant equipment**

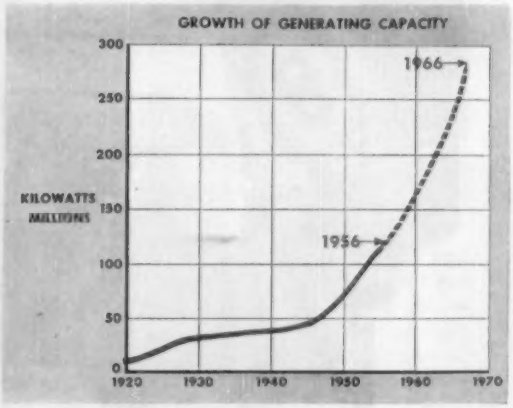
CAREFUL PLANNING FOR PRODUCTIVE MAINTENANCE INCLUDING STOCKING SPARE PARTS

How *Productive* Maintenance can help



THE FACILITIES of the world's finest turbine plant and 46 service shops located throughout the country back your General Electric unit.

TO MEET TOMORROW'S EXPANDING LOADS



G.E. works with electric utilities and consulting engineers in these vital turbine-generator areas:

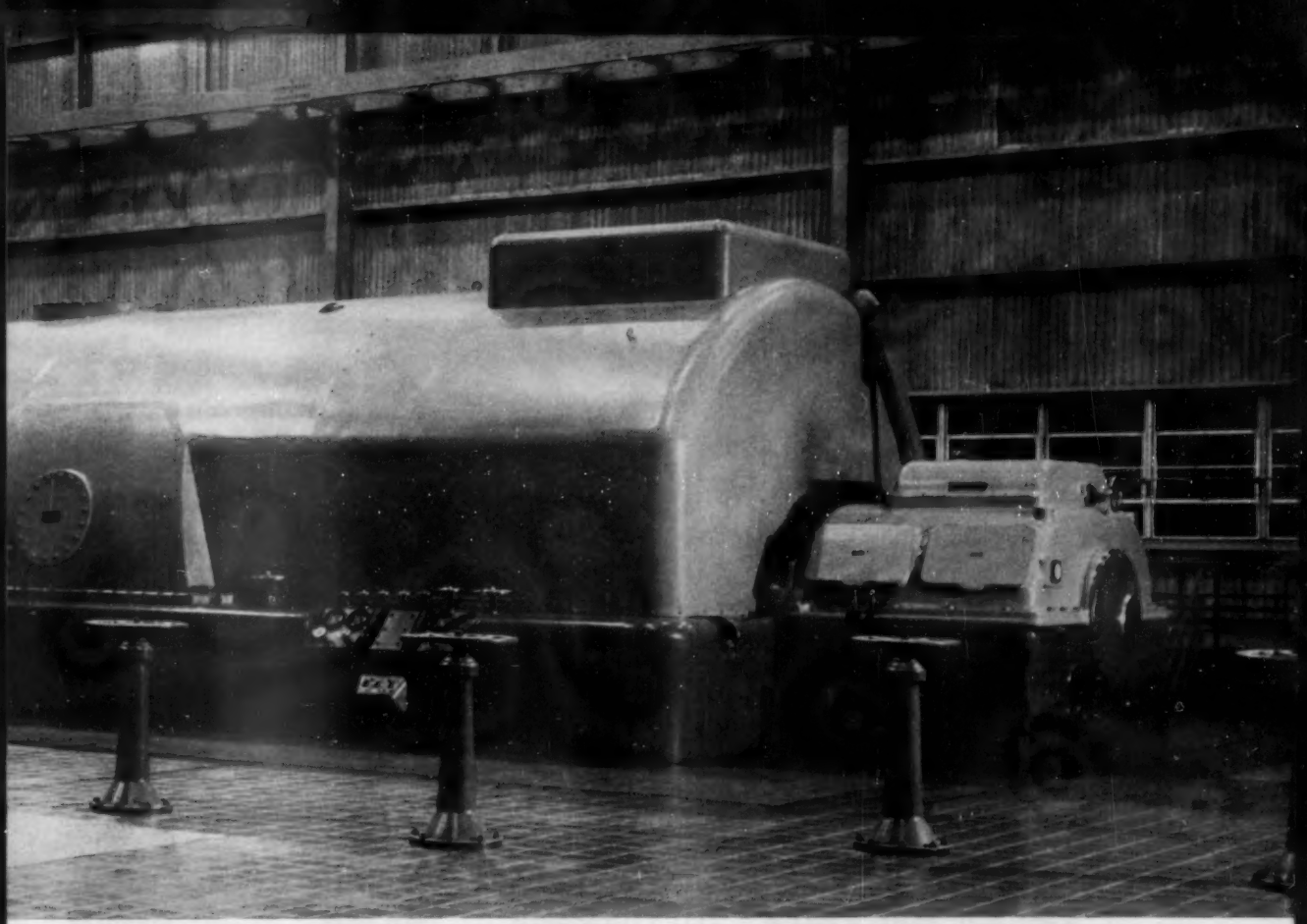
BASIC RESEARCH

APPLIED RESEARCH

PRODUCT DEVELOPMENT

TESTING

MAINTENANCE: PRODUCTIVE MAINTENANCE



AND REVIEWING SCHEDULED OVERHAULS CAN REDUCE TURBINE-GENERATOR DOWNTIME.

keep a turbine-generator on-the-line

General Electric's *Productive* Maintenance plan can help you reduce turbine-generator maintenance expenses. Here's how:

1) Maintaining a supply of General Electric spare parts can save valuable time. These parts fall into three categories:

a) Recommended parts such as thrust rings, springs for packing seals, brushes and brush holders, gaskets for control mechanisms, studs and nuts;

b) Optional spares such as rings for packing seals, bushings for control mechanisms, bearings and sealing rings for oil pumps; and

c) Major parts such as main bearings, rotors and stator bars.

G.E. can help you decide which to carry.

2) By using General Electric renewal parts and inspection service you get complete and accurate information about construction and engineering characteristics for your G-E unit. This means fast service and thorough engineering. General Electric is familiar with your machine and at the time of planning overhauls can suggest possible modernization.

3) With the trend toward more uniform loads throughout the year—both summer and winter—scheduling outages is becoming a real problem. Your General Electric turbine-generator representative can help you plan your overhaul schedule. By applying G.E.'s *Productive* Maintenance plan, and where operating conditions warrant, it may be possible to extend the time between overhaul periods.

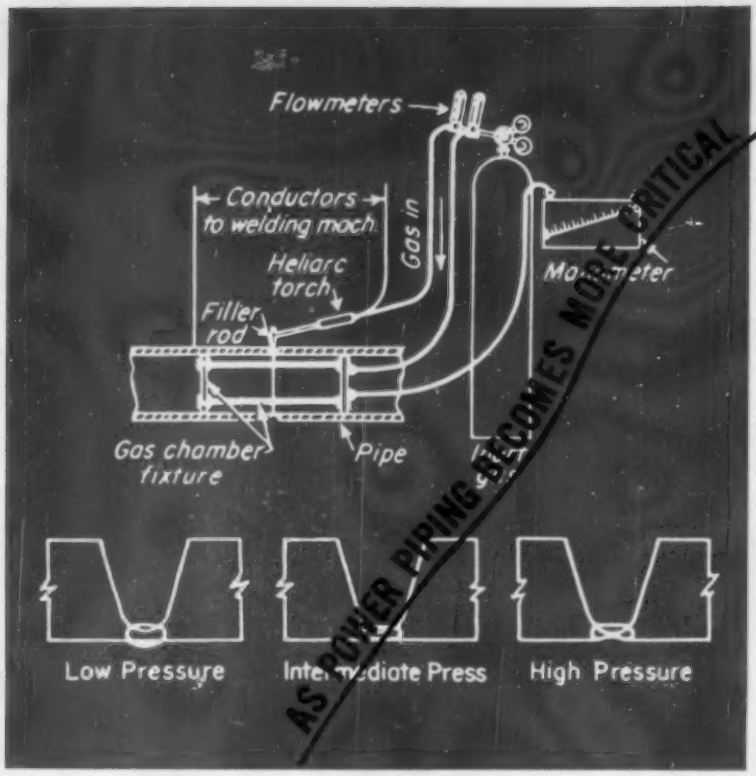
You can get service 24 hours a day, seven days a week if necessary on your General Electric unit. The world's most modern turbine-generator manufacturing facilities and 46 G-E service shops are ready to help you.

Planning *Productive* Maintenance is just one of many areas in which General Electric is co-operating with electric utilities to prepare for tomorrow's load growth today. For more information write for bulletin GEA-6087. Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, New York.

254-46

Progress Is Our Most Important Product

GENERAL ELECTRIC



KELLOGG'S FIELD WELDING TECHNIQUES KEEP PACE

With main and reheat steam piping for steam-electric power plants becoming heavier and more difficult to handle because of increasing wall thicknesses, more and more of the welding previously done in fabricators' shops must be handled in the field. This, coupled with the need for still better welding techniques to combat higher operating pressures and temperatures, demands even higher standards of design and workmanship to compensate for the less favorable conditions often encountered in the field.

One way in which M. W. Kellogg sets the pace in field fabrication is with K-Weld*—Kellogg's unique inert gas shielded technique of arc welding. With K-Weld, complete penetration and a highly uniform internal contour are assured without the use of backing rings. Incorporating a Kellogg development which controls internal gas pressure and shape of the interior weld surface automatically, K-Weld is recognized as the ultimate in welding techniques for any type or size of alloy piping—both for shop and field fabrication.

A 12-page booklet, "For The Modern Central Power Station," describes K-Weld and other M. W. Kellogg facilities for the design, fabrication, installation, and testing of main and reheat steam piping.

K-Weld root bead is laid while the pipe interior is under controlled inert gas pressure in the gas chamber fixture. Diagram at top of page shows detail of this portable gas chamber fixture and how interior weld surface is controlled by varying pressure.

K-Weld is always under the supervision of a Kellogg inspector, supplementing final radiographic inspection. In addition, a permanent chart record is made on the potentiometer of all steps in welding and stress relieving.

FABRICATED PRODUCTS DIVISION

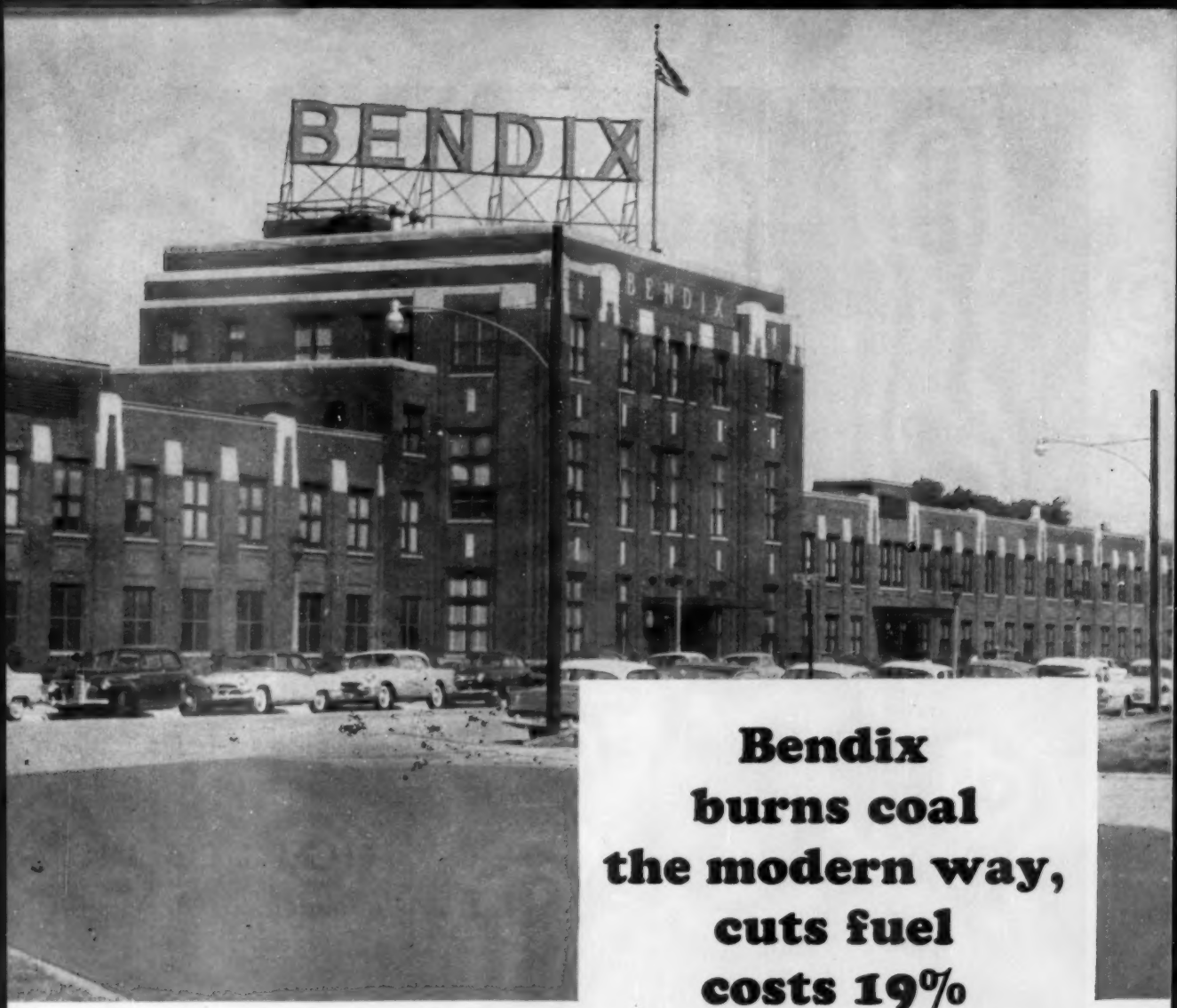
THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Ltd., Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York • Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

**Trademark of and patented by The M. W. Kellogg Company*

POWER PIPING—THE VITAL LINK



Bendix burns coal the modern way, cuts fuel costs 19%

Consult an engineering firm

Designing and building hundreds of heating and power installations a year, qualified engineering firms can bring you the latest knowledge of fuel costs and equipment. If you are planning the construction of new heating or power facilities—or the remodeling of an existing installation—one of these concerns will work closely with your own engineering department to effect substantial savings not only in efficiency but in fuel economy over the years.

facts you should know about coal

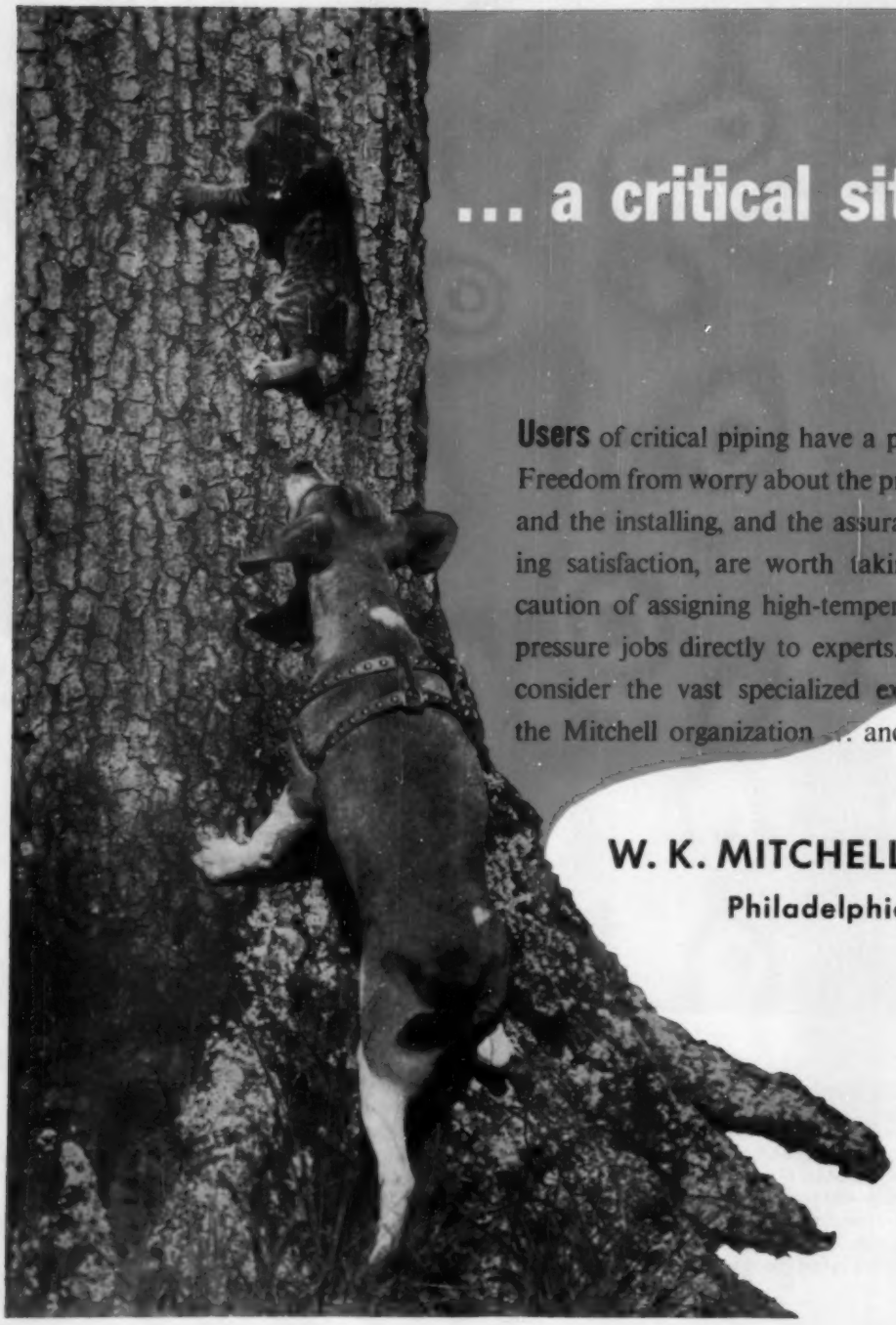
In most industrial areas, bituminous coal is the lowest-cost fuel available • Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar • Automatic coal and ash handling systems can cut your labor cost to a minimum. Coal is the safest fuel to store and use • No smoke or dust problems when coal is burned with modern equipment • Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.

At its Products Division, South Bend, Ind., Bendix Aviation Corporation undertook extensive modernization of its power system. The firm replaced two 511 HP boilers with two 80,000 lb./hr. spreader stoker fired units. A 500-ton overhead bunker and coal elevator-conveyor system were installed. Additional changes were made including an increase in the capacities of the water and air systems.

Today fuel costs at Bendix have been cut 19%, efficiency boosted from 70% to 82%, maintenance costs lowered 80% and availability upped from 50% to 96%. By burning coal the modern way, Bendix is saving many thousands of dollars yearly and will amortize the cost of modernization in a comparatively short time.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

BITUMINOUS COAL INSTITUTE
Southern Building • Washington 5, D. C.



... a critical situation

Users of critical piping have a problem too. Freedom from worry about the prefabricating and the installing, and the assurance of lasting satisfaction, are worth taking the precaution of assigning high-temperature, high-pressure jobs directly to experts. Next time, consider the vast specialized experience of the Mitchell organization ... and ask us in.

W. K. MITCHELL & CO., INC.
Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

SURGEABILITY...

THE LATEST WORD IN WATER TREATMENT

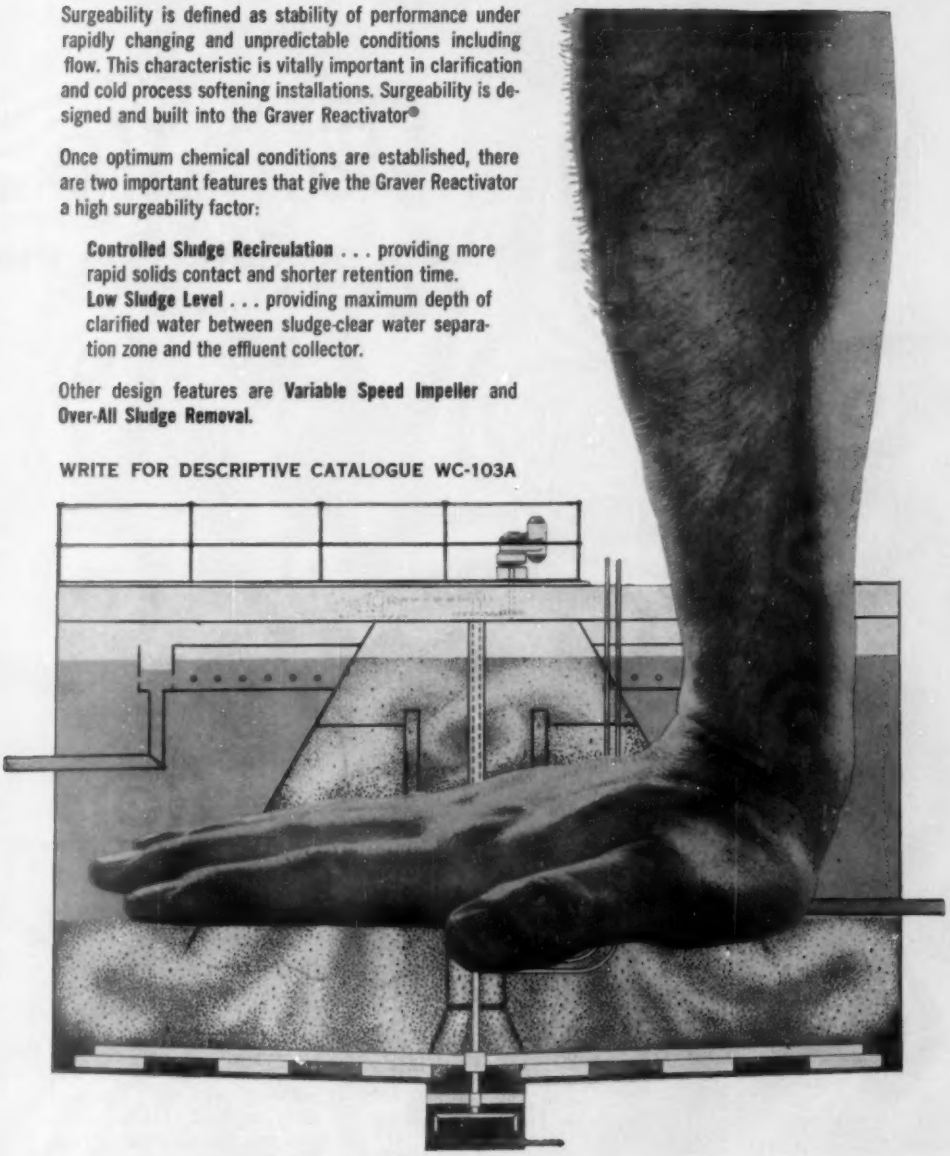
Surgeability is defined as stability of performance under rapidly changing and unpredictable conditions including flow. This characteristic is vitally important in clarification and cold process softening installations. Surgeability is designed and built into the Graver Reactivator®

Once optimum chemical conditions are established, there are two important features that give the Graver Reactivator a high surgeability factor:

Controlled Sludge Recirculation . . . providing more rapid solids contact and shorter retention time.
Low Sludge Level . . . providing maximum depth of clarified water between sludge-clear water separation zone and the effluent collector.

Other design features are **Variable Speed Impeller** and **Over-All Sludge Removal.**

WRITE FOR DESCRIPTIVE CATALOGUE WC-103A



Department NK

GRAVER

GRAVER WATER CONDITIONING CO.

A Division of Graver Tank & Mfg. Co., Inc.

216 West 14th Street, New York 11, N. Y.

Coal

. . . low in sulphur
. . . low in ash
. . . low in moisture

Coal

. . . HIGH in btu's
. . . HIGH in satisfaction
from producers on the C&O

For dependable deliveries of top quality coals, contact coal producers on the C&O. And if you need help in meeting your own particular fuel requirements, write to: R. C. Riedinger, General Coal Traffic Manager, Chesapeake & Ohio Railway Company, Terminal Tower, Cleveland 1, Ohio.

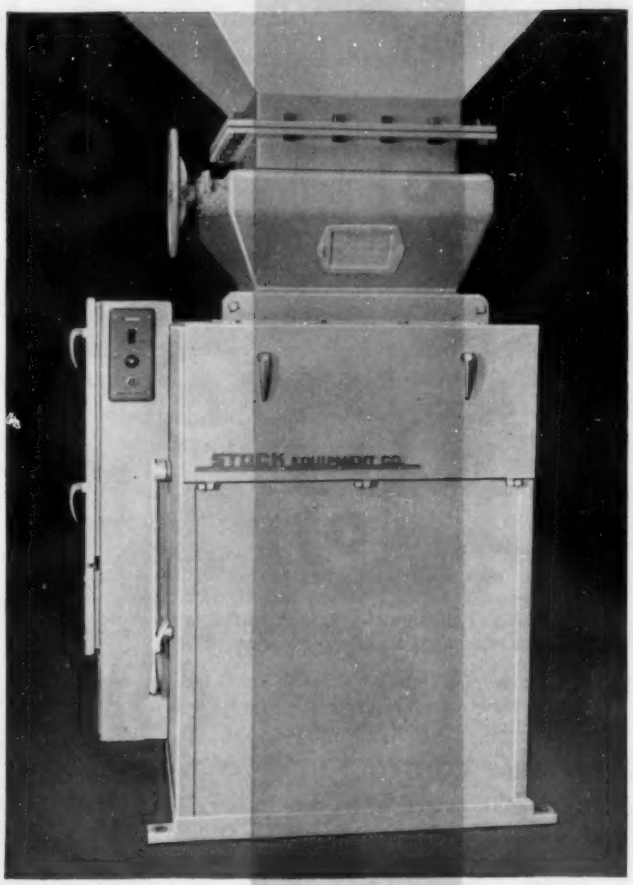
Chesapeake and Ohio Railway

WORLD'S LARGEST CARRIER OF BITUMINOUS COAL

24"

STRAIGHT THROUGH

No Restrictions . . .
No Baffles . . .
No Sloping Skirts



The *new* **S-E-Co. Model 50 Coal Scale** has been designed to eliminate coal stoppage difficulties. This scale makes it possible for you to get maximum accuracy of weight of coal burned for boiler tests, to keep inventory records, and to balance mills without danger of coal plugging and hanging up.

The inlet of the Model 50 is 24" inside square — the vertical feeder skirts carry a 24" stream of coal — and the stainless steel weigh hopper has a 24" wide outlet.

In addition, the large, rigid and well gasketed doors of the Model 50 maintain a clean installation that is easy to service. Roller bearings on the weigh hopper gate and other carefully worked out improvements make this scale of tomorrow the scale for you today.

SPECIALISTS IN
BUNKER TO PULVERIZER AND
BUNKER TO STOKER EQUIPMENT

STOCK Equipment Company

745-C HANNA BLDG., CLEVELAND 15, OHIO

BEST BURNER BIG BOILERS

...C-E Tilting, Tangential Burner

Nearly 450 C-E Boilers with an aggregate capacity of well over 200-million pounds of steam per hour are now in service proving the advantages of firing with C-E Tangential Burners. And another 125 units are under construction or on order. The more important of these advantages are:

BETTER COMBUSTION

Tangential firing is fundamentally the best method of firing any fuel – coal, oil or gas – particularly in big furnaces. Here's why:

1. The extreme turbulence created by impinging flame streams of adjacent burners assures the most effective mixing of all the air with all of the fuel to produce the most rapid and complete combustion.

2. The swirling, rotating travel of combustion gases fills the furnace cross-section and utilizes the heat absorbing wall surfaces most effectively.

SUPERHEAT CONTROL

Virtually all tangential burners in large C-E utility boilers are of the vertically adjustable (tilting) design. This feature provides, in addition to the exceptional combustion efficiency inherent in tangential firing, a degree of superheat temperature control which cannot be achieved with any other firing method. Here's how:

1. If steam temperature goes too high, the C-E Tilting, Tangential Burner nozzles *automatically* tilt downward. More furnace wall surface becomes effective. Gas temperature to superheater surface is lowered. *Steam temperature comes down.*

2. Conversely, if steam temperature drops below that efficient for the turbine, nozzles tilt upward, sending hotter gases to the superheater. *Steam temperature goes up* – automatically.

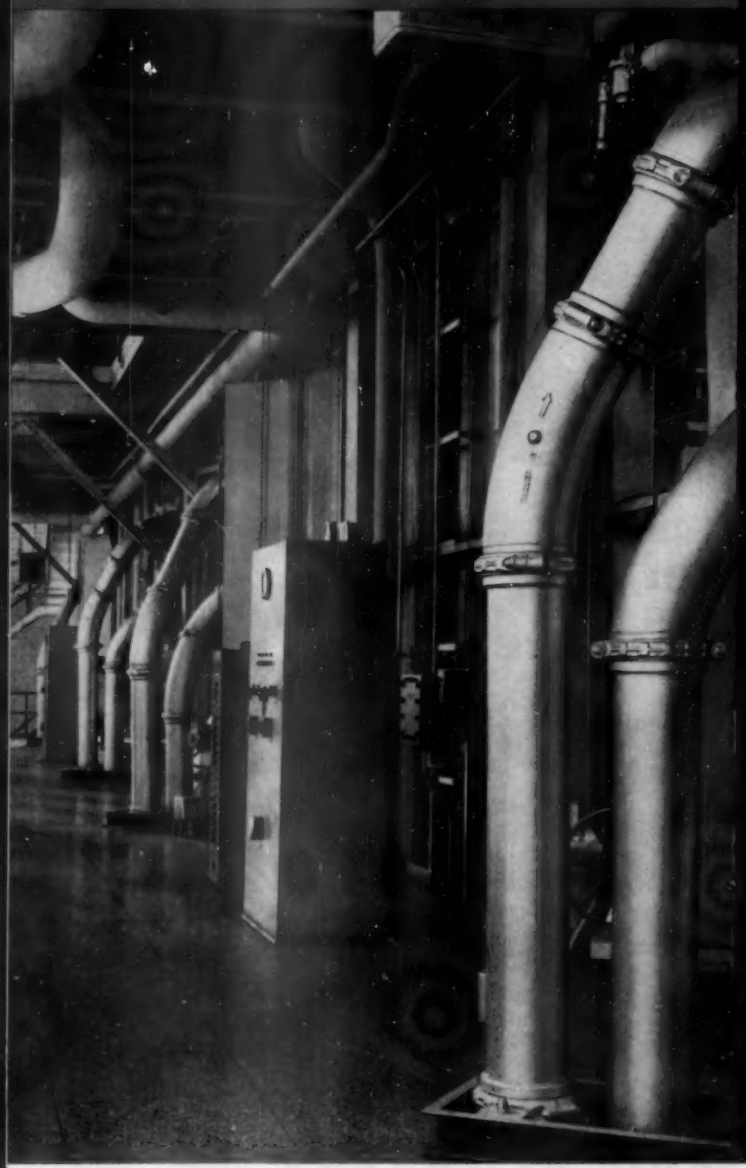
As a result, the minimum gas temperature necessary to assure proper superheat is maintained. There is little need for desuperheating . . . minimum use of spray water . . . less chance of fouling turbine blades. Turbine availability is higher . . . efficiency is maintained.

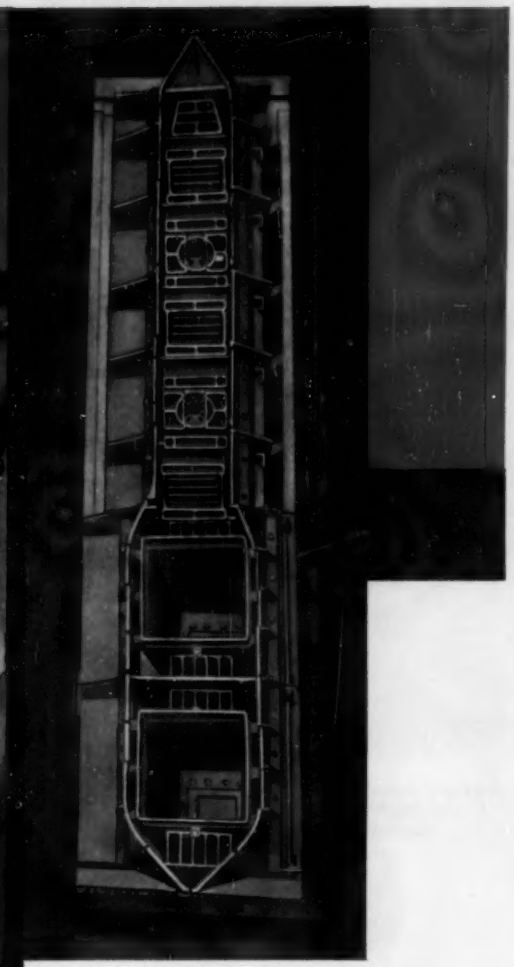
In the most important areas of performance, therefore, the tangentially fired unit has established itself *in service* over a period of many years as the best method of firing for big boilers. More recently it met similar success in smaller oil and gas fired units for capacities as low as 50,000 lbs of steam per hour.

A new catalog, PC 8, gives many more details. May we send you a copy?

C-E Tangential Burners are now shop assembled with adjacent furnace tubes in place. The illustrations below and at left clearly indicate the resulting advantages in transportation, handling and installation.

FOR





▲ **The versatility of the tangential burner is well illustrated by this rather special design, made for a wide variety of fuels. This burner has nozzles for coal, oil, coke oven gas and — at the bottom — blast furnace gas. The latter is stationary--the rest are adjustable.**

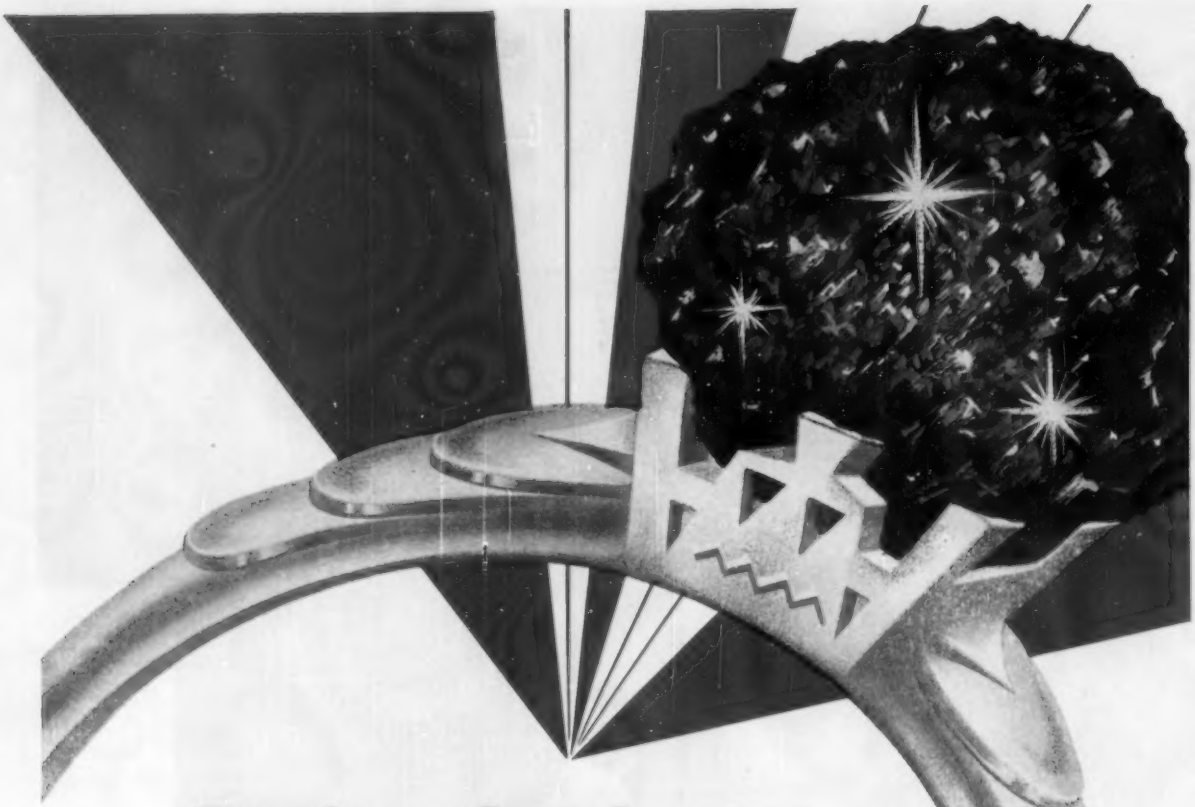
◀ **This view of the firing floor of a large tangentially fired C-E utility boiler shows the clean-cut, uncluttered appearance which is typical of units of this type.**

COMBUSTION ENGINEERING

B-961

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

STEAM GENERATING UNITS • NUCLEAR REACTORS • PAPER MILL EQUIPMENT • PULVERIZERS • FLASH DRYING SYSTEMS • PRESSURE VESSELS
HOME HEATING AND COOLING UNITS • DOMESTIC WATER HEATERS • SOIL PIPE



Precious Jewel of Industry's Future

"Black Diamonds" are America's most valuable resource for today and tomorrow! Only Bituminous coal can fully meet industry's needs for more electrical energy and more plant-power.

Convenient reserves of B&O Bituminous offer an unlimited supply of coals for every purpose, at low-cost. *Ask our man!*

LET OUR COAL TRAFFIC REPRESENTATIVES suggest a B&O Bituminous for your needs.

COAL TRAFFIC DEPARTMENT B&O RAILROAD
Baltimore 1, Md. LExington 9-0400

BALTIMORE & OHIO RAILROAD

Bituminous Coals For Every Purpose

LINKING 13 GREAT STATES WITH THE NATION B&O ®

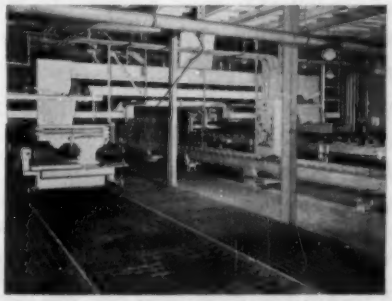
General View of Holtwood Steam Station
Pennsylvania Water and Power Co.
Ebasco Services Incorporated
Consulting Engineers.

Bartlett-Snow coal handling at Holtwood

● Coal handling facilities in this plant, that burns anthracite coal dredged from the river and reclaimed by the floatation process, were engineered by Bartlett-Snow to Ebasco specifications, fabricated in our shops, and installed by our erectors. The equipment includes combination receiving and reclaim hopper fitted with vibrating feeders, a 360 ton per hour conveyor system, 36″ cantilever storage conveyor; and two 42″ shuttle conveyors for wet coal and a 14″ screw conveyor for dry coal in the distributing room over the bunkers.

For fixed responsibility that insures highly efficient, synchronized operation of all parts of the system as a unit, and low maintenance and low operating costs — let the Bartlett-Snow coal handling engineers work with you on your next new plant, modernization or plant expansion program!

View of 36″ Cantilever Storage Conveyor Anchored Permanently on a Hollow Concrete Silo that Withstands Avalanching of Coal.



View of Two 42″ Wide Shuttle Conveyors for Wet Coal and 14″ Diameter Screw Conveyor for Dry Coal in Distributing Room Over the Bunkers.

DESIGNERS
ENGINEERS

BARTLETT-SNOW
CLEVELAND 5, OHIO

FABRICATORS
ERECTORS

"Builders of Equipment for People You Know"

GAS CLEANING NEWS

Eastern Public Utility Installs Two More Koppers Electrostatic Precipitators to Remove Fly Ash

Major Utility has installed 8 Koppers Electrostatic Precipitators since 1947

YEARS of cost-saving, highly efficient performance preceded this latest installation of Koppers Electrostatic Precipitators. During these years, this leading Eastern public utility was able to judge Koppers by on-the-job operation—the most positive proof of performance.

Proves Performance on the Job

Ten years ago, this company purchased its first two Koppers Electrostatic Precipitators for fly ash removal. Satisfactory performance and low maintenance costs justified the purchase of additional Koppers units that were installed in a total of 4 stations. The eight units furnish highly effective, trouble-free operation in a varying range of CFM capacities.

Supplies a Wide Range

The eight Koppers Electrostatic Precipitators serve boilers ranging in capacity from 570,000 #/hr to 950,000 #/hr. Guaranteed efficiency runs as high as 98%, depending on the need of each application. This ability to engineer for a wide range of capacities enables Koppers to satisfy the needs of each station.

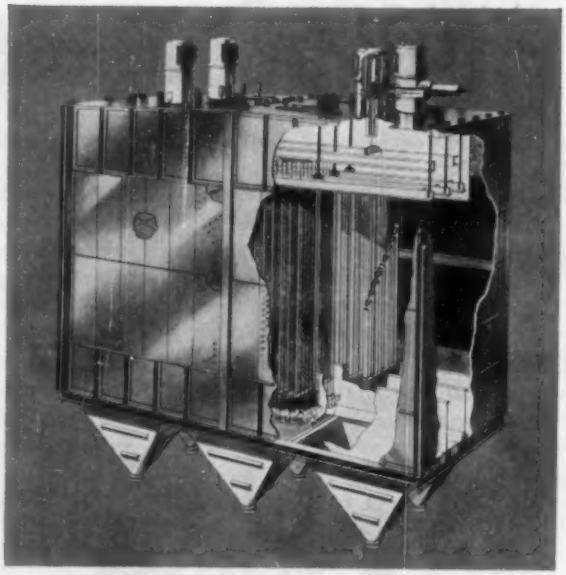
Meets Individual Plant Needs

Koppers custom-designs each Electrostatic Precipitator. Koppers units remove boiler fly ash before the flue gas is discharged from the stack. In designing Electrostatic Precipitators, Koppers utilizes its knowledge of the characteristics of various coals, types of boilers and methods of firing.

Backed by Know-How

Koppers gas cleaning experience goes back 75 years. This experience is backed up by extensive research facilities at Verona, Pa., and Baltimore, Md. From this experience and research has come gas cleaning equipment for all sizes and types of plants.

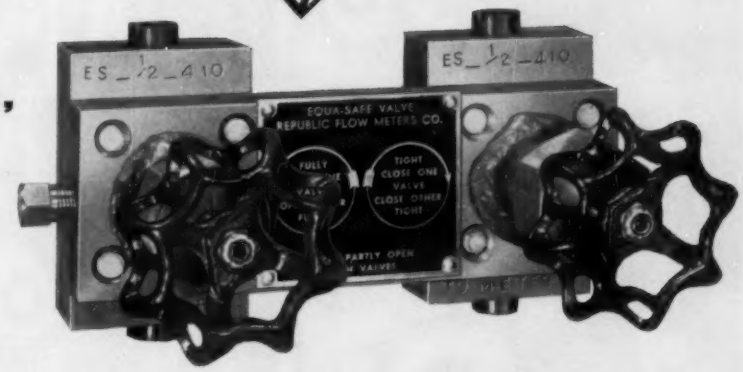
Get the most out of your gas cleaning dollar. Write KOPPERS COMPANY, INC., Metal Products Division, Industrial Gas Cleaning Dept., 4411 Scott Street, Baltimore 3, Maryland.



This cutaway photo of a Koppers Electrostatic Precipitator shows shell, vibrators, and collecting and discharge electrodes. The actual design and arrangement of elements vary widely because Koppers Electrostatic Precipitators are custom-engineered to fit the requirements of each installation.

NOW AVAILABLE

Valve Manifolds that STOP Mercury Blowing, Damage to Differential Bellows and Diaphragms



- **CANNOT throw full line pressure across bellows, mercury or diaphragms of ΔP instruments.**
- **Replaces 3 or 4 conventional shut-off valves, fittings, etc.**
- **Rated to 4000 psi (cold)**
- **Available with angle, 3-way or through-type bodies threaded or socket- welded connections.**

No conventional built-up valve manifold affords the protection EQUA-SAFE *automatically* gives to differential pressure type instruments. And no built-up valve manifold can beat the low installation time or low maintenance required by EQUA-SAFE valves.

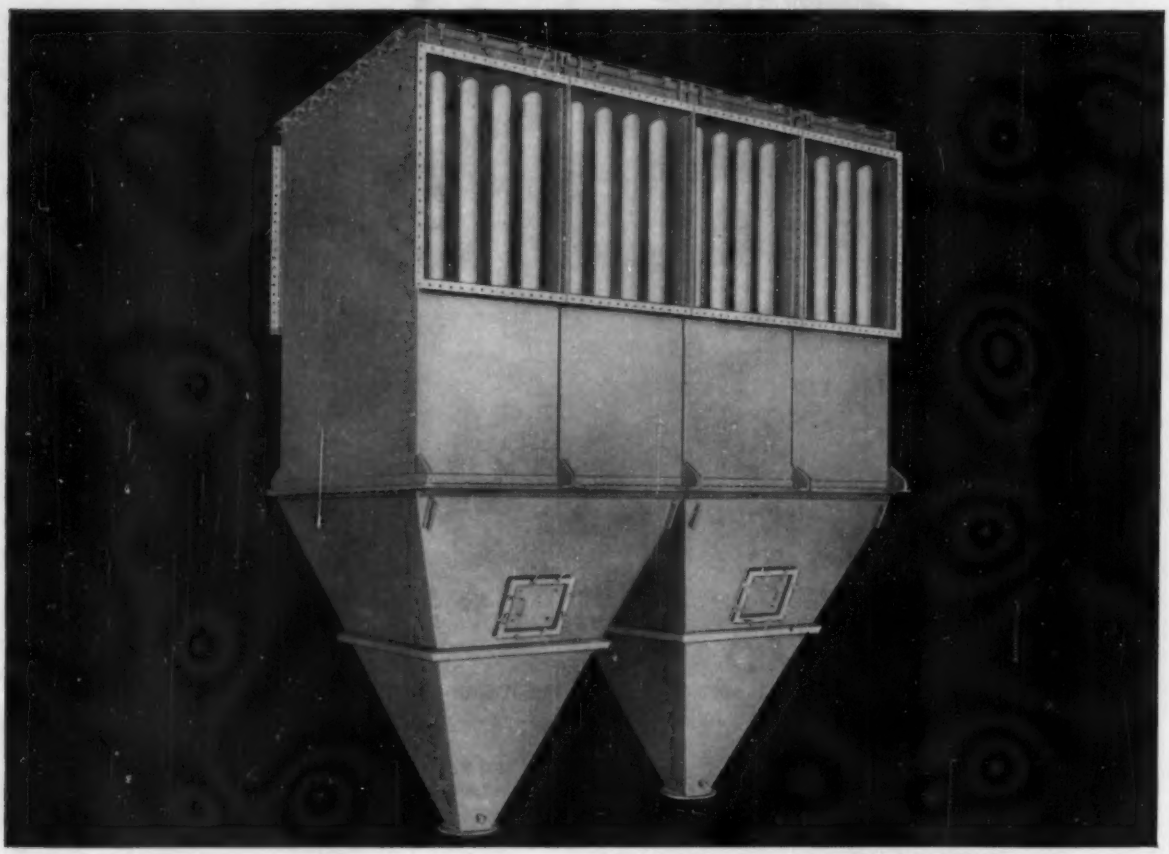
The "secret" of EQUA-SAFE's protection is in the common bridge-type bonnet and the two double-seating valves it connects. *When either valve is operated* (and sequence does not matter) *pressures in the two chambers of the differential instrument are automatically equalized through the bonnet.* As soon as both valves are fully "opened" (stem out) the instrument is on the line, with no leakage between sides. When both stems are in, the instrument chambers are interconnected and completely sealed off from primary connection pressures. Teflon packings are under pressure only while the stems are traveling from "seat" to "backseat", or vice versa!

Standard EQUA-SAFE valve manifolds are made of carbon and/or stainless steel, depending on your requirements. If your requirements are unusually severe, remember that EQUA-SAFE valves can be made of *any bar stock material that can be machined and welded!* When inspection or maintenance are needed, this bolted-block construction pays off again. EQUA-SAFE valves can be completely dismantled without breaking any pipe connections, and the inlet seat can be dressed up in place. A reversible backseat ring gives double wear, and is merely turned upside down to present a brand new seat.

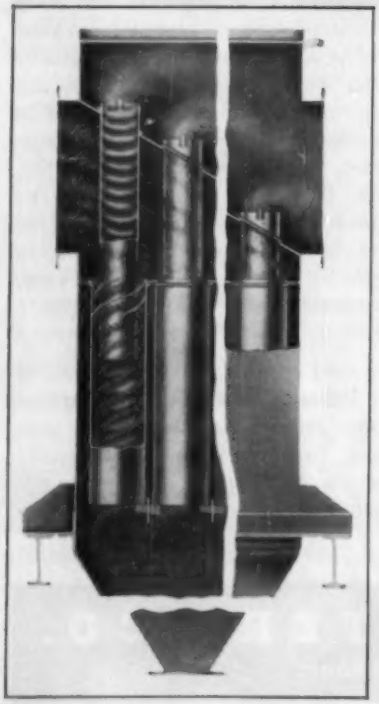
Get the entire story on what EQUA-SAFE valves can do for your differential instrument installations. Write for Republic Bulletin No. 56-1, or ask your Republic engineer. Now that there is a top-quality instrument valve manifold for ΔP instuments, you should definitely investigate its applications in your plant.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

Control fly ash with job-fitted



Series 342 Precipitator



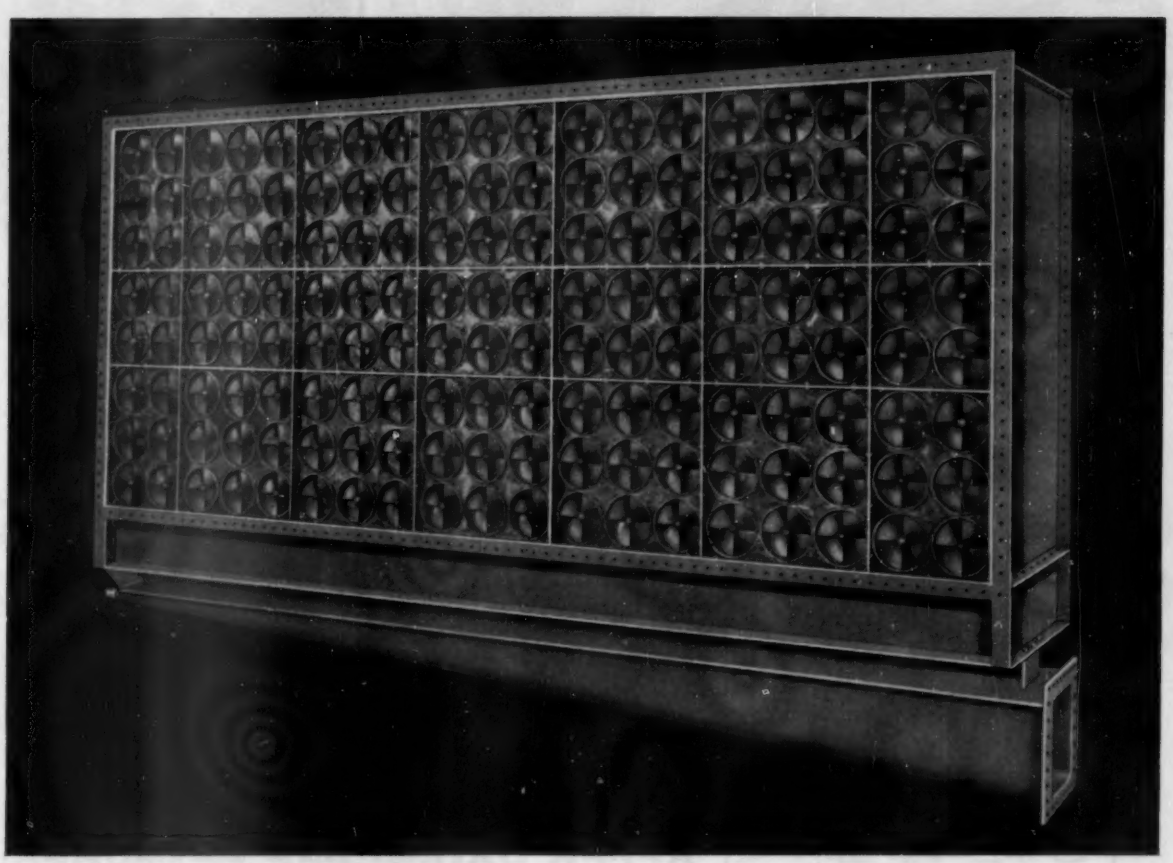
COMPACT DUST COLLECTOR — Series 342 Precipitator meets industry's need for a simple, compact, economical, all-purpose, mechanical-type dust collector. With the growing value of fly ash as a salable by-product, adequate, efficient collection is becoming increasingly important.

Easy to install because of its sectionalized construction, the Series 342 Precipitator has proved effective in controlling dust discharge to the atmosphere in a large percentage of industrial plants. The reason: since each tube assembly is basically an individual cyclone or centrifugal dust collector, the multi-tube Series 342 will deliver an over-all performance comparable to the high efficiency obtained by a single, small-diameter cyclone.

Furthermore, American Blower Series 342 Precipitator features welded-steel construction and removable tubes, is available in a variety of sizes to meet specific job requirements on either new or existing installations.

Dust-laden air or gas enters inlet plenum; gravity and centrifugal action force dust downward, adjacent to tube wall; dust is skimmed into gas-tight receptacle; cleaned air or gas moves upward through outlet tubes to outlet plenum.

American Blower precipitators

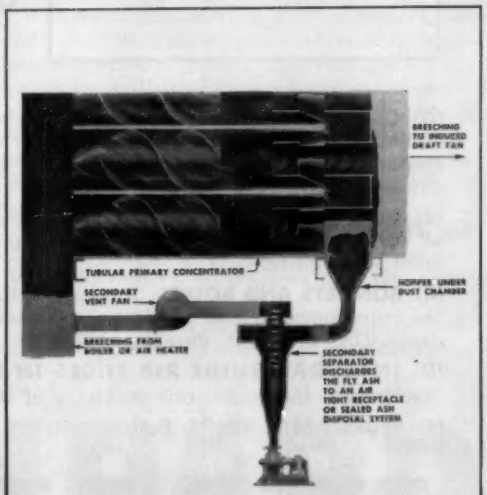


Series 361 Fly Ash Precipitator

FOR LARGE PUBLIC UTILITIES – Series 361 Fly Ash Precipitator offers maximum collection efficiency over entire operating range, occupies minimum space, and gives reliable performance, trouble-free operation.

What's more, the secondary separating system of the Series 361 makes it relatively more efficient at reduced loads when fly ash is finer and more difficult to remove. Then, too, ability to vary number and arrangement of individual cells makes it easy to tailor unit to the particular job.

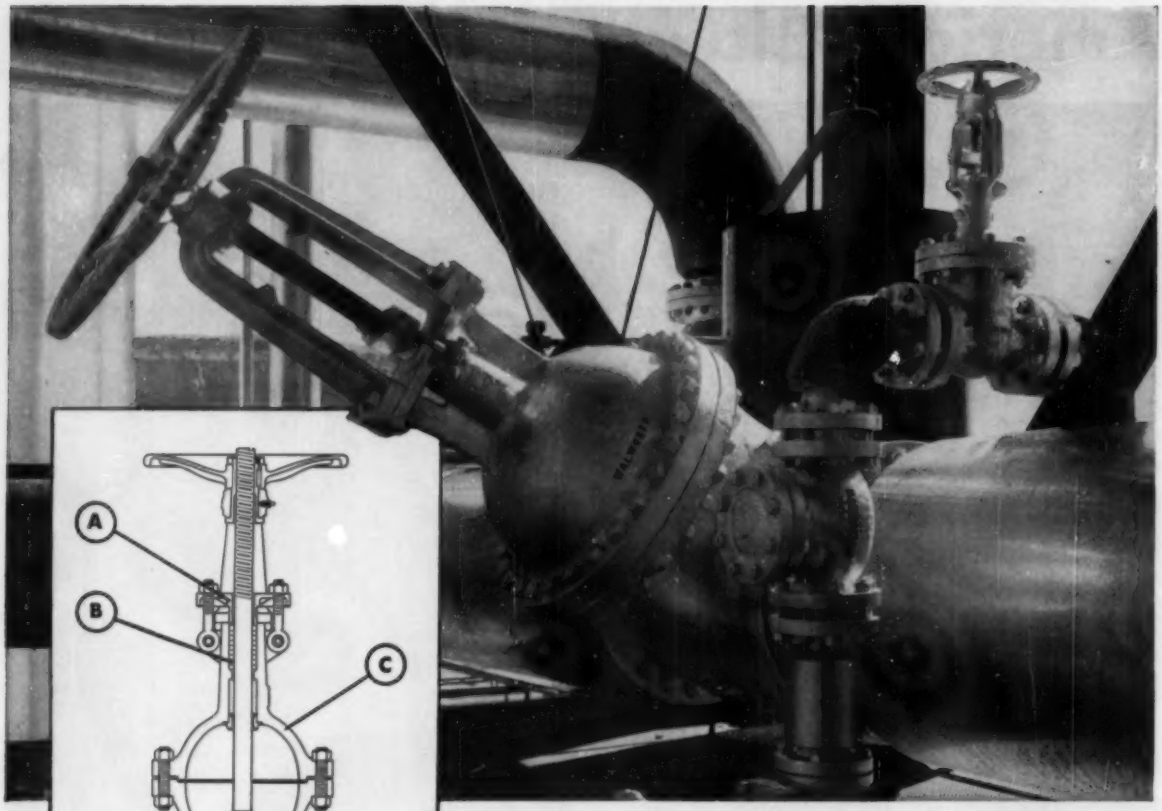
Whatever your dust-collection problem, it will pay you to talk to an American Blower engineer. His knowledge of the application of precipitators and dust collectors can prove invaluable to you. Call your nearest branch, or write: American Blower Corporation, Detroit 32, Michigan. In Canada: Canadian Sirocco products.


BREECHING TO INDUCED DRAFT FAN
TUBULAR PRIMARY CONCENTRATOR
SECONDARY VENT FAN
HOPPER UNDER DUST CHAMBER
BREECHING FROM BOILER OR AIR HEATER
SECONDARY SEPARATOR DISCHARGES THE FLY ASH TO AN AIR TIGHT RECEPTACLE OR SEALED ASH DISPOSAL SYSTEM

Secondary system results in velocity-efficiency characteristics which automatically maintain maximum efficiency over entire boiler load or operating range. Properly installed and operated, unit's collection efficiency is from 85% to 90%.

AMERICAN BLOWER

Division of AMERICAN-Standard



Walworth Series 150 and 300

CAST STEEL GATE VALVES OFFER YOU THESE FEATURES

for 'round-the-plant service

(A) GLANDS: Clearances between the gland and stuffing box, and gland and stem, are such that the stem cannot be scored even if the gland is pulled down unevenly.

(B) DEEP STUFFING BOXES: More than adequate in all sizes (2″ to 24″) to assure tightness and maximum packing life.

(C) BONNETS AND BODIES: Engineered to exceed the requirements of all applicable codes and standards. They are tough, durable, dependable.

(D) INTEGRAL GUIDE RIB FACES IN BODY: Machined to insure accurate centering of the gate.

(E) STURDY SEAT RINGS: Bottom-seated so that no recess exists at the back of the ring to cause turbulence, erosion and pressure drop.

(F) STREAMLINED PORTS: Permit unobstructed flow which results in minimum pressure drop and reduces the possibility of erosion.

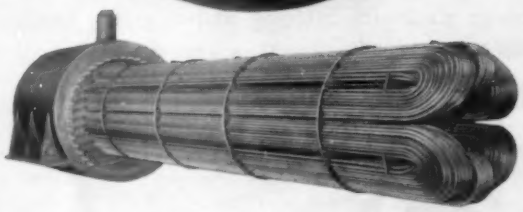
Walworth Cast Steel Gate Valves can be furnished with either flanged ends or butt welding ends. Roller bearing yokes are available on the larger sizes. On valves 4 inches and larger, by-passes can be furnished. Walworth Cast Steel Gate, Globe and Check Valves from Series 150 to 2500, are available. For Series 600 and higher, we recommend Walworth Pressure Seal Cast Steel Valves. See your Walworth Distributor or write to Walworth for complete information.

WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION M & H VALVE & FITTINGS CO. SOUTHWEST FABRICATING & WELDING CO., INC. WALWORTH COMPANY OF CANADA, LTD.

Highest Standard in Boiler and Pressure Tubing



Every length of Standard Boiler and Pressure Tubing is tested at pressures far beyond code requirements and can be readily bent or otherwise fabricated.

Electric welded boiler tubing is used today by all of the leading manufacturers of boilers and superheaters—stationary, marine, and locomotive—high or low pressure—and meets the requirements of government and commercial specifications.

With recent changes in the A.S.M.E. Boiler Code, it's now possible to use electric weld boiler tubing at pressures in excess of 2,000 lbs. High strength" Grade C" tubes are available for even higher pressures.

Uniformity of temper and wall thickness makes Standard tubes easier to roll for tight . . . sure fit. Standard's fine, smooth surface eliminates any need to polish ends for tight fit. Even a microscope won't spot the exact location of the weld.

Nowhere will you find any more modern and complete facilities for precision manufacture and inspection of Boiler and Pressure Tubing than you'll find at Standard.

For complete information on all Standard products and services send for free 8-page folder today.

Free 8-page folder on all Standard products. Write address below.

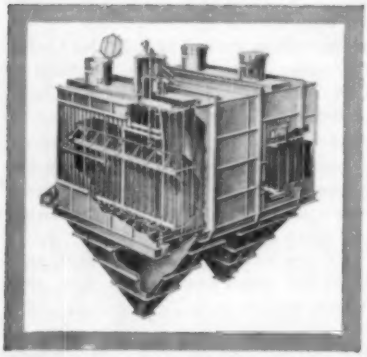
STANDARD

THE STANDARD TUBE COMPANY

24400 PLYMOUTH ROAD • DETROIT 39, MICHIGAN

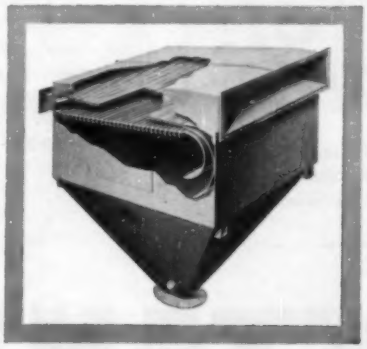
Welded stainless tubing and pipe • Welded carbon steel mechanical • Boiler and Heat Exchanger • Exclusive rigidized patterns • Special Shapes • Steel Tubing – Sizes: ⅜" OD to 5¼" OD – .028 to .260 wall • Stainless – Sizes: ¼" OD to 4¼" OD – .020 to .165 wall.

How Buell's exclusive Shave-off pays off in extra dust collection efficiency



Buell SF Electric Precipitator also delivers extra dust collection efficiency, due to unique Spiralectrodes and Continuous Cycle Rapping.

Proper proportioning, side entry of dust-laden gases, add even more extra efficiency and long, maintenance-free life to Buell Cyclones. Large diameter design eliminates bridging and clogging, keeps efficiency high under varying loads.



Buell Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or mechanical draft installations.

For more specific data about Buell's *extra efficiency*, write Dept. 70-K, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell®

MECHANICAL ELECTRICAL *Experts at delivering Extra Efficiency in* **DUST COLLECTION SYSTEMS**

COMBUSTION
Editorial

A Hopeful View of the Atom

"There never was a time in history in which I would rather live than today."

These were words of Dr. Edward McCrady, president and vice chancellor of the University of the South, as he addressed a luncheon gathering on September 25 marking the shipment of the shell of the 235-ton reactor vessel for America's first full-scale nuclear power station from the Chattanooga, Tenn., plant of Combustion Engineering, Inc. See page 48–49.

Why should a huge mass of steel involving unprecedented fabrication problems inspire such words? Should not the atom's destructive rôle in military conflict occasion a more sober pessimism? Can one really be optimistic in the world of today and see prospects for a brighter future with the peaceful atom?

Dr. McCrady neither posed nor answers these questions for the assembled group of business executives, representatives of government and members of the press. But he did set forth a philosophical point of view relating to them that justified his zest for living in this period of history. As one trained in biological science and now engaged in the leadership of an outstanding educational institution, Dr. McCrady has come to learn of the limitations of extreme specialization, on the one hand, and overemphasis on generalities, on the other. He is firmly convinced, therefore, that the scientist (and engineer) must be educated more broadly so as to become familiar with the accumulated knowledge in the humanities as well as in science. Narrow specialization is inadequate for scientists in a world in which they must bear unprecedented responsibility for the social and economic outcomes of their laboratory creations.

The most encouraging evidence, as Dr. McCrady pointed out, is that the ancient alchemist's dreams of transmuting elements have become today's realities, in large part due to the success of those who have learned to apply the scientific method. It is a truism that only human beings can dream and apply the scientific method. The basis of optimism for the present and the hope for the future is that the scientists and engineers will make use of their historical heritage in the liberal arts to make certain that the atom is put to use for the benefit of all mankind.

Feeding the Thirst for Knowledge

Our function as a publication can be very briefly presented in an excerpt from the policy statement drawn up at the time of our formation. This statement defined as its aim "the accurate interpretation and dissemination of news concerning present-day practice, new developments and future trends in the fields of fuel burning and steam generation." As a result of our charge we try to keep particularly conscious of the various means and methods employed to disseminate and interpret technical information. Meetings of engineering societies and the engineering sections of trade and business associations are rich areas for continued observation as to ways and means of acquainting active practitioners with engineering developments. Some meetings and some speakers, in particular, seem much more effective than do others.

On October 18 and 19 the prime mover section of the Pennsylvania Electric Association met on the property of the Long Island Lighting Company for a symposium on water conditioning. The participants were a select group numbering about 100. One of the authors displayed an illustration of a damaged boiler tube with accompanying photo-micrographs as part of his paper. Immediately the audience came alive and one of the best exchanges between speaker and listening group that we have witnessed took place. To our mind such exchanges should be the prime objective of all technical meetings. They illustrate to us a continuing thirst for more knowledge and a challenge to program planners and editors alike to improve and persist in the dissemination of information. We congratulate the program committee of the PEA and its interested members for proving to us again the value of the engineering meeting. For our part we shall try to uphold the value of the technical press in our mutual struggle to answer the inquiring engineer.

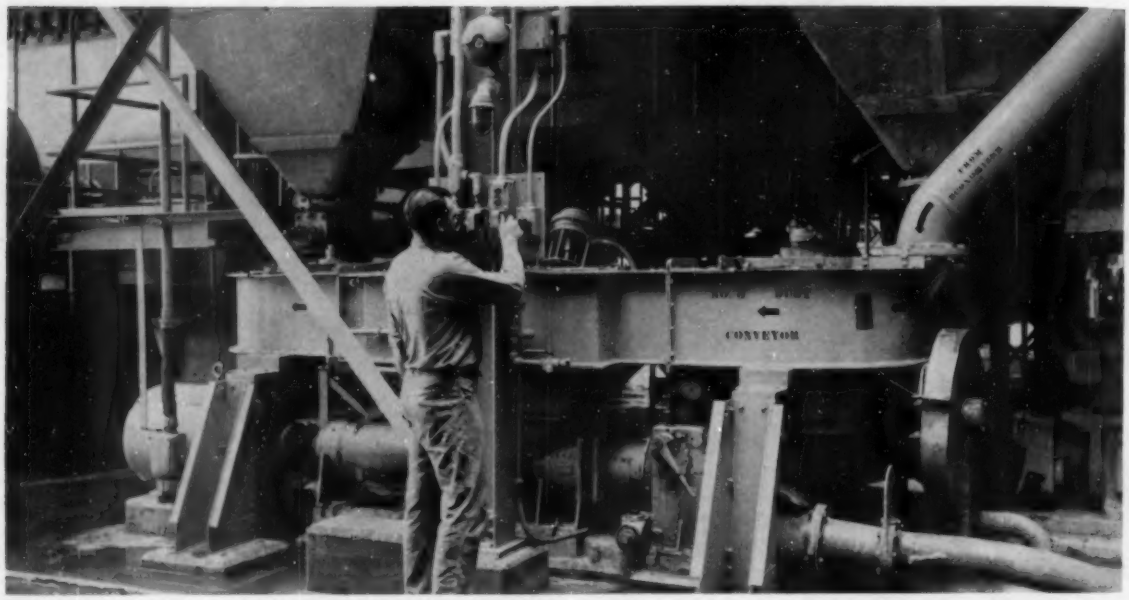


Fig. 6—Rotary valves under the dust collector hoppers move the dust into the "flight-in-trough" conveyors which, in turn, supply the dust pump (shown below conveyor), and from there to a refiring silo

Fly Ash Refiring[*]

By WALLACE W. MAULL† and EARL C. McMAHON††

Public Service Electric and Gas Co.

Over the past 25 years, the problem of fly ash disposal has been a pressing one. The ever increasing attention given to stack emission demands that fly ash be collected and disposed of as efficiently as possible. As a result many methods have been suggested. This paper discusses the refiring method of disposal.

FLY ash, as used here, consists of ash particles which normally would fly up the stack unless collected in some way. We use the words "fly ash" or "dust" to mean the same thing.

On the other hand, the remainder of the ash, which settles to the floor of the furnace, is known as "slag" or "mineral granules." All the boilers referred to in this discussion have "wet" slag bottom furnaces.

When coal is burned, ash is formed as we all know. When, in turn, the fly ash is reinjected into the furnace to be burned again, we say it is "refired."

All of the heat of the combustible in the fly ash plus the heat of the furnace itself raises the temperature of the fly ash to a point above 2800 F at which point it becomes molten slag. In this white hot condition, it flows over the floor to the slag tap and spills into the ash tank below. Upon striking the water in the tank, it forms black crystals; hence its trade name of mineral granules or slag.

In most cases the purpose of refiring fly ash is to get rid of it by turning it into a more disposable or salable product. This saves storage space and the cost of removal later. However, where combustible in the ash is considered excessive, refiring this ash and recovering the heat value in it improves the overall efficiency.

Introduction and History

Back in the late thirties, the Public Service Electric and Gas. Co. installed its first boilers equipped to burn pulverized coal. It was known that a considerable percentage of the coal ash would go out the stack unless some means of cleaning the flue gases was used. Electrostatic precipitators seemed to be the answer and, more recently, electrostatic precipitators in combination with mechanical separators have been used to remove the fly ash from the flue gas.

Each of our generating stations was adjacent to unused property onto which it was thought the slag from the furnaces and the fly ash from the precipitators could be pumped. It wasn't long, however, before it became evident that the areas would quickly become filled. Further, in pumping this material to these areas the slag fell near the end of the discharge pipe whereas the fly ash tended to stay in suspension and would spread

* Presented at the 19th Annual Joint Solid Fuels Conference, ASME and the American Institute of Mining, Metallurgical and Petroleum Engineers, Washington, D. C., October 25, 26, 1956.

† Chief Engineer, Marion Generating Station.
†† Chief Engineer, Sewaren Generating Station.

Fig. 1—First step in fly ash refiring at Marion Station is the collection hopper of the fly ash precipitators, such as above

Fig. 2—Water-cooled sheet metal nozzle, above, serves as actual admission point for returning fly ash

out over much of the area where, on occasion, it would dry out and be blown in all directions by the wind.

Fortunately industry gradually was finding uses for the slag resulting from the firing of pulverized coal. Some cement block manufacturers were using it as aggregate and a manufacturer of composition shingles was interested in obtaining clean slag from Marion Generating Station.

FRONT-FIRED BOILERS

Field Development—Dust Ram

The two pulverized coal-fired boilers installed at Marion Generating Station (See Table I, Fig. 11, for data and boiler cross-section) in 1941 had provision for the future installation of a dust ram for feeding fly ash to the primary furnace through each side wall at a point about $2^1/_2$ ft above the furnace floor and 2 ft from the front wall. These furnaces are completely water-cooled with a slag screen, fired through the furnace roof by six intertube burners in two rows. Slag is continuously removed through a water-cooled opening in the center of the furnace floor.

A dust ram which had been tried out unsuccessfully at another location was installed on one side of one of these boilers in April 1942. The fly ash was dropped by gravity from the bottom half of the precipitator hoppers (see Fig. 1) through 4-in. pipes which eventually joined in a 6-in. vertical line. This line in turn, carried the fly ash to a rotary feeder located just above the ram.

The ram consisted of a $4^1/_8$-in. diam water-cooled piston operating in a water-cooled sleeve. Compressed air was used inside the ram packing to prevent dust from escaping into the boiler room and compressed air was also used to supply a ring of nozzles located in the furnace end of sleeve. The rotary feeder capacity was 50 cfh.

Observations of preliminary operation indicated that 70 lb of air pressure on the sleeve nozzles resulted in good dispersion of the dust in the furnace. The more the air pressure was reduced below that point, the more dust fell to the furnace floor to form a pile. For 12 days, interrupted by a two-day outage due to the feeder motor having burned out when the feeder was stopped by a metal ring from the precipitator, operation appeared to be entirely satisfactory. The precipitator hoppers remained empty and the gas passes gave no indication of slagging up.

Conditions were not so good as they seemed, however. On the twelfth day of operation, water was observed on the furnace floor and the sound of escaping steam could be heard near the dust ram. The dust carried by compressed air had eroded the wall tubes on each side of the hole through which the fly ash entered the furnace.

While the wall tubes were being repaired, a new piston sleeve and cylinder liner was installed in the dust ram and instead of using the air nozzles in the sleeve, an independent, removable, $^1/_4$-in. air nozzle was installed under the piston opening, directed upward at an angle of 45 degrees. Measurements were taken so that it would be positively known that the nozzle was always beyond the furnace side of the wall tubes. The theory was that as the dust would be pushed into the furnace by the ram, aided by air from the lantern seal, it would be dispersed by air from the nozzle. Actually, however, only part of the fly ash was dispersed; the remainder fell to the furnace floor to form a pile. Frequently, the pile of unmelted dust completely surrounded the ram and nozzle and it was feared that there might be turbulence in the pocket between the pile of dust and ram, again causing erosion of the wall tubes. At this point, the use of the air nozzle was discontinued and the air pressure on the lantern seal was limited to 10 lb.

It was with considerable surprise to most of us that the dust ram continued to operate fairly satisfactorily while using so little compressed air. During periods of reduced load, the pile of fly ash would grow so the ram

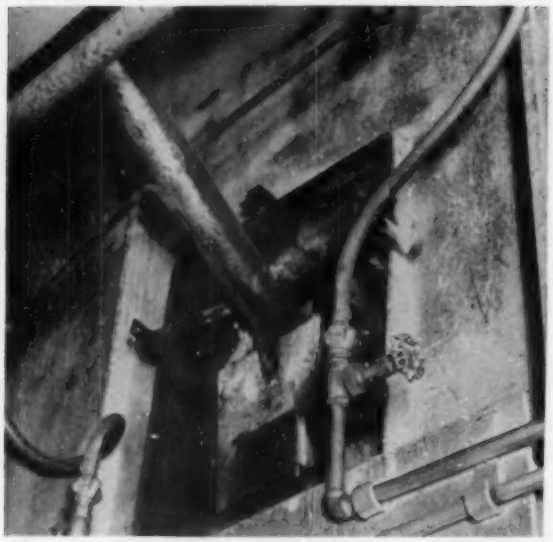


Fig. 3—Fly ash moves down piping at an angle of about 45 degrees to flow into the nozzle, Fig. 2

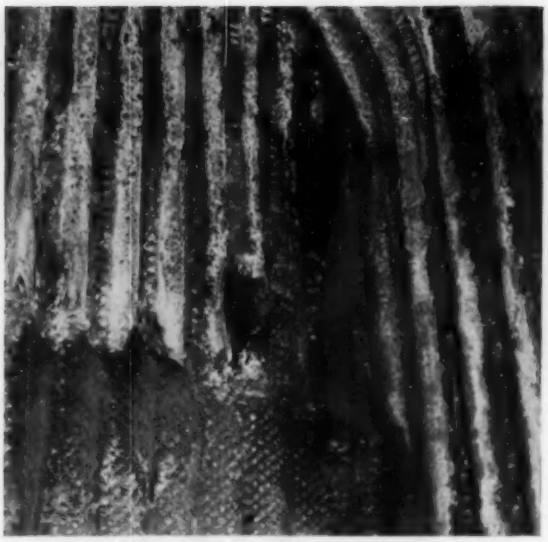


Fig. 4—The nozzle assembly is placed in the furnace chamber with the open end facing the floor

would be completely hidden, but dry dust could usually be seen either flowing over the top of the pile or coming out through the sides of the pile. The dust pile usually melted down slowly when carrying full load on the boiler so that there was seldom a time when the pile was over 3 ft in height. When the pile did seem to be getting too high, the fly ash was removed from the precipitator hoppers to the disposal area by means of the hydrovactor system until the dust pile had melted down.

In January 1943, after 6000 hr of Dust Ram Operation, it was found necessary to send the ram assembly to the manufacturer for overhaul; the piston sleeve having worn to a considerable extent and it having been continually more difficult to keep the fly ash from leaking through the seal into the boiler room.

It was proposed that the necessary piping be installed and the other three dust rams be purchased and installed as originally planned.

Those who had nursed the dust ram for nine months were unhappy with the prospect of three additional rams to operate and maintain. It was their thought that the fly ash should be fed to a hotter zone in the furnace where it would melt immediately. The opportunity to try out other methods of refiring came while the ram was away for repairs.

Refiring Dust at Oil Burner Position

At each coal burner there were two oil burner positions, one of which it was thought could be used to introduce the fly ash. The rotary feeder was moved to an elevation above the burner platform from which point a 6-in. flexible pipe carried the dust to a "home-made" 6- × 3-in. reducer which, in turn, was connected to a 3-in. header, with a slope of 45 degrees, above the front row of three burners. A $1^1/_2$-in. connection with valve was taken off the header above each burner. A $1^1/_2$-in. flexible tube was used for the connection to the $1^1/_2$-in. dust burner pipe which could be inserted the same as an oil burner. Provision was made for introducing compressed air at each $1^1/_2$-in. take-off from the header.

The oil burner positions were first used for refiring fly ash in September 1943. This method of refiring was so well liked that a similar installation was made on the opposite side of the boiler, being placed in service in December 1943.

For two years the oil burner positions were used for refiring fly ash but the installation could not be said to be free from troubles. The flow of dust through the $1^1/_2$-in. nozzles was so concentrated that piles of dust did form on the floor under each nozzle. These piles at times would form a dam across the furnace behind which the molten slag would collect. At these times refiring was stopped rather than run the chance of having the dust piles pushed over the slag tap opening. The $1^1/_2$-in. burner pipes were also a cause of frequent plugging by lumps of fly ash.

Refiring Through Observation Door

The next move was made in November 1945 when the observation door opening located in each side wall 4 ft below the furnace roof and 2 ft from the front wall was selected as a location for introducing the fly ash. A rectangular sheet iron nozzle was made to go through the opening at an angle of 45 degrees and completely fill the space. The furnace end of the nozzle was flush with the wall tubes with an opening measuring 2 × 7 in. A compressed air connection was made under the rotary feeder to aerate and help convey the fly ash.

Slag running down the side walls tended to partially cover the nozzle interfering with the free flow of dust. Next, a water-cooled sheet metal nozzle was made up with the furnace end perpendicular to the sides. With this design of nozzle, its upper side extended into the furnace and the flowing slag interfered less with the flow of fly ash but something was still wrong. Examination of the nozzle provided the clue which led to the design of a successful dust nozzle. Slag was found several inches up on the bottom of the nozzle indicating that the heat from the coal burner was causing the fly ash to fuse before it reached the end of the nozzle. Another water-cooled

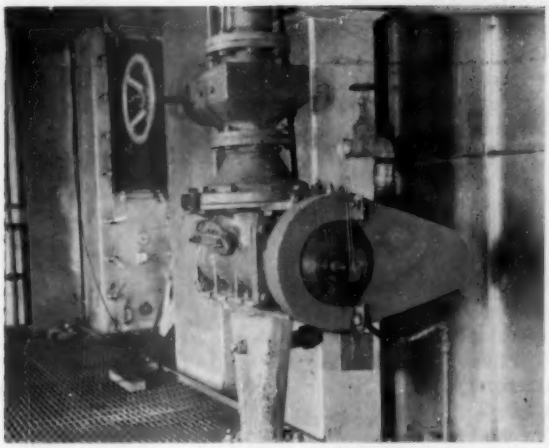


Fig. 5—A special 2-in. line draws air from the fd fan duct to aerate and carry fly ash into furnace

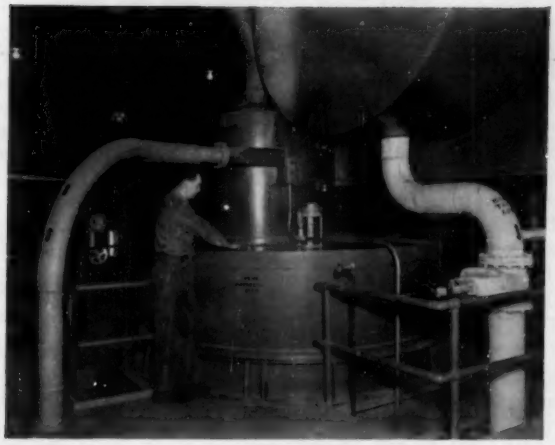


Fig. 7—Dust refiring silo is pictured above at the Sewaren Station

sheet metal nozzle was made up with the open end parallel to the furnace floor, thus shielding the dust from the direct heat of the flame (see Figs. 2, 3, and 4).

Fly Ash Refiring at Marion

After five years of development, it was possible to say that fly ash could be successfully refired in the one boiler at Marion Generating Station. A similar fly ash refiring system was soon installed on the second boiler and it can honestly be stated that for the six years starting in 1947, during which pulverized coal was the fuel being burned, practically no fly ash from the precipitators had to be pumped to the disposal area.

It has been the belief of the operators at Marion Station that part of the success achieved in refiring the fly ash resulted from having selected the right observation door through which to place the nozzle. The circulation of gas in the furnace seems to be upward at the nozzle, tending to pick up the fly ash as it is discharged from the nozzle and carry it through the flame before it has a chance to fall to the floor or leave the primary furnace.

One change has been made since the original installations. Air taken through a 2-in. line from the forced draft fan air duct has been substituted for the compressed air formerly used below the rotary feeders to aerate and convey the fly ash (see Fig. 5.)

Since the average fusion temperature of fly ash is about 2800 F, the refiring of fly ash was stopped by closing the valves under each precipitator hopper each night before the load drop took place. Refiring was restarted in the morning after both pulverizers were in service. At first, the clearances in the rotary feeders were so great that when the hopper gates were opened in the morning, or when the precipitator rappers went into service, the full head of the fly ash would force its way through the feeders and cause a furnace "blackout." The result at the time of these occurrences was a rapid drop in steam flow accompanied by as much as a 50 degree increase in superheater steam temperature. The clearances in the feeders were reduced to a minimum and the quantity of fly ash that a feeder could handle was reduced to a point at which it would take 4 to 6 hr to completely empty the dust hoppers and lines each day.

There was no apparent effect from fly ash refiring on boiler operation aside from the necessity of removing slag from the ash tanks every 4 hr instead of once in 8 hr. There was recirculation of fly ash indicated by tests showing increased concentration of dust in the flue gas entering the precipitators and by the fact that the induced draft liners lasted only half as long when refiring fly ash. No test showed greater than twice the concentration of fly ash entering the precipitator when refiring and there was no change in the good appearance of the gas leaving the stack.

Moisture was the greatest source of trouble in the operation of the fly ash refiring system. Fly ash seems to have a great affinity for moisture. It was even possible that the moisture in the compressed air originally used to convey dust to the nozzle caused some of the plugged lines. After every time an air preheater was washed or the boiler was out of service for more than a few hours it took many hours to get the fly ash to flow freely again.

One result of refiring fly ash was the collection of iron in almost pure form on the furnace floor. It seemed quite certain that the iron was the result of returning fly ash to the furnace because with the dust ram in service the iron was all in the floor near the ram, whereas when using the oil burner positions, the greatest concentration

TABLE I—MARION GENERATING STATION NO. 51 AND 52 BOILERS

Manufacturer	Babcock & Wilcox
Type boiler	Radiant
Capacity, lb/hr	550,000
Pressure, lb/sq in. gage	1,475
Temperature, F	950
Furnace volume, cu ft	
Total	23,500
Primary	7,750
Heating surface, sq ft	
Primary furnace	2,406
Secondary furnace	3,942
Boiler	7,194
Combustion rate, Btu/hr/cu ft at 550,000 #/hr steam	27,300

Representative Analysis of Fly Ash

Combustible, %	6.33
Calorific value, Btu/lb	924
Passed thru No. 400 sieve, %	80.5
Retained on No. 60 sieve, %	1.5
Fusion temperature, F	2,800

of iron was found under the three positions which had been used for introducing the fly ash. The boiler manufacturer was not disturbed by the presence of iron in the floor but it did cause several unscheduled boiler outages. When the furnace cooled during periods of low load operation, the iron on the floor would contract leaving cracks along the walls and around the slag tap cooling coil. It was through these cracks, in a few instances, that the molten slag escaped from the furnace floor. During the last few years when burning pulverized coal, it has been a yearly job to remove a foot wide strip of the iron and slag from along the walls and from around the slag tap coil and to pack the area with chrome ore. This practice eliminated the slag leaks.

There has always been a wide diversity of opinion as to just how much of the ash in the coal became slag immediately and how much left the furnace as fly ash. At Marion Generating Station, a rough check was made which gave the following results:

Ash to slag immediately, %	..	27	27
Fly ash to economizer hoppers (to disposal area), %	..	9	..
Fly ash refired, %	51	..	..
Fly ash to stack (lost), %	13	..	..
Fly ash entering precipitators, %	..	64	..
Total ash recovered as slag, %	..	..	78

During 1952, the last full year of operation on pulverized coal, approximately 296,000 tons of coal were burned from which was recovered about 18,600 tons of slag and 2500 tons of bagged fly ash. A typical approximate analysis (dry basis) of the coal burned that year was:

Volatile matter, %	21
Fixed carbon, %	69
Ash, %	10
Sulfur, %	2.4
Calorific value, Btu./lb	13,700
Fusion temperature, F	2250
Fly Ash melting temperature, F	2800

During a precipitator test made on one boiler in 1947, an attempt was made to gather enough additional data to be able to get the approximate boiler efficiency when not refiring fly ash and when returning all the fly ash to the furnace. The accuracy of the results are questionable but they indicated a better than 1 per cent increase in boiler efficiency when refiring fly ash.

TANGENTIAL OR CORNER-FIRED BOILERS

Dust Collection System—Mechanical Section

In order to refire fly ash satisfactorily in a tangentially fired or corner-fired boiler, the dust collection system must be adequate in size and must be absolutely waterproof, just as in front-fired boilers.

At Sewaren Generating Station one boiler is equipped to refire fly ash. The unit is 1500 psi, 1050 F, 52,450 cu ft furnace volume, 15,080 sq ft boiler heating surface. The boiler is rated at 850,000 lb per hr continuous—950,000 lb per hr for 4 hr. Three levels of combination coal and oil burners, vertically adjustable, tangential, corner-firing, are employed in the design (see Fig. 13 for cross-section).

The flue gas leaves the boiler, passes through the air preheater and then through the mechanical dust collectors, which are the centrifuge cone type. This collector type consists of 780 tubes so installed that the flue gas spirals down around the outside of the tube. A quick reversal in the gas direction up through the inside of the tube causes the heavier dust particles to be thrown down into the dust hopper. Experience shows that the hopper must be absolutely weatherproof or else the dust becomes sticky and difficult to move (see Fig. 6.)

Electrical Precipitator

From the dust collectors, the flue gas, minus most of its dust, passes through the electrical precipitator. The fly ash particles, passing through a 50-kv to 70-kv electrostatic charge between the electrode wire and collecting screen, become charged and attach themselves to the

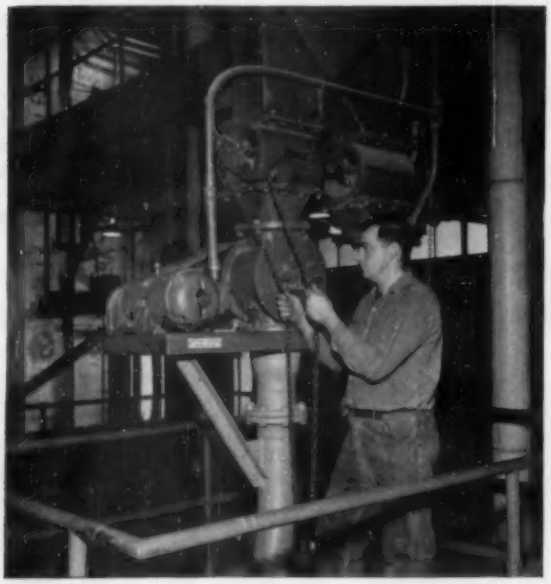


Fig. 8—Rotary valve beneath silo has openings checked to prevent heavy dust flow packing downcomer

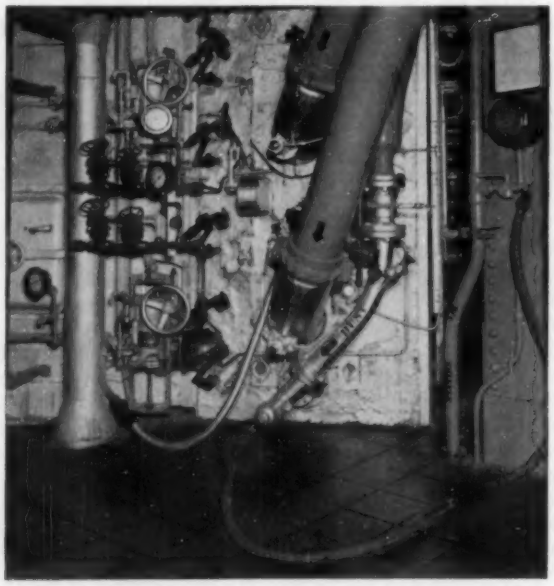


Fig. 9—Dust nozzle at Sewaren is a straight piece of pipe, horizontal to the furnace floor

collecting screen. Air hammers cause the dust to fall from the screen into the hopper. Rotary valves under the hoppers move the dust into the flights-in-trough type conveyor (see Fig. 6.)

When we first used this system, some moisture got into the rotary feeders causing them to seize. At another time during cold weather, moisture got into the system and froze. This necessitated the complete disassembly of each of the rotary valves, a thorough cleaning and reinstallation.

It was also found to be necessary to install "inching" buttons so that in cold weather the rotary feeder valves could be operated a little each shift and kept free of trouble.

From the "flight-in-trough" system, the dust is pumped by means of the dust pump (see Fig. 6) to the dust refiring silo (see Fig. 7.) This, too, must be kept airtight to prevent clogging.

The fly ash flows from the dust refiring silo down through a rotary valve to a downcomer pipe. The rotary valve was found to pump more dust than could be properly refired. Therefore, the openings of the rotary valve were reduced so as to prevent "packing" the downcomer pipe. Before this measure was taken, some plugging in the downcomer was experienced (see Fig. 8.)

Fig. 9 shows the dust nozzle which is merely a straight piece of pipe, horizontal to the furnace. Dust flows through it at a point about $1^1/_2$ ft above the furnace floor. It is set directly below all burners in the corner of the furnace.

In order to transport the dust to the furnace, air at 100 psi is used. A $^1/_4$-in. orifice, together with a valve, regulates and restricts the air flow to the dust nozzle. If too little air is used, the dust merely falls out the end of the nozzle and piles up on the furnace floor, eventually backing up in the dust line. If too much air is used, the dust is blown all around the furnace, thereby cutting down the radiant heat to the walls and resulting in a 10 F to 15 F rise in superheat temperature.

As in the front-fired boiler, it was found desirable to refire the fly ash about 4 to 6 hr per shift, for the 8 a.m. to 4 p.m., and 4 p.m. to 12 n. shifts, or when the load is at least 80 per cent normal load. In this manner the slag is formed in not too great quantities and at a steady rate. A minimum load of 80 per cent for refiring makes it certain that the furnace will be hot enough to melt the fly ash and cause it to run smoothly.

Once the proper rate of dust flow has been determined, and the flow of air at the nozzle has been finally adjusted, the refiring method becomes routine and requires only a matter of minutes every shift for good operation.

Essentials of Refiring

We found the following practices helpful in refiring fly ash with minimum attention:

(1) The fly ash was kept absolutely *dry*. Three per cent to five per cent moisture would cause plugging. In a very dry state, the fly ash may readily be transported from collecting hoppers to the dust nozzle.

(2) A *uniform rate* of fly ash fed to the nozzle made smoother refiring and also smoother slag formation.

(3) The fly ash was introduced at sufficiently *hot location* of the boiler to raise the fly ash to the fusion point which is about 2800 F and to sustain the temperature.

(4) Care was taken to see that the fly ash was *finely divided*, not lumpy.

(5) The fly ash was *aerated* at the refiring nozzle.

Refiring At Kearny

At the Kearny Station, the new tangentially-fired boilers are pressurized. The boiler steam generation is 1,055,000 lb per hour, at 2350 psi with 1100 F throttle and 1050 F reheat temperature.

At Kearny, refiring is done through a nozzle located just above the bottom coal burner in a corner of the boiler. Station air of a small amount is used to transport the dust into the furnace, against the furnace pressure. The air also helps to disperse the dust.

Refiring at Essex

The boiler installed in Essex Generating Station in 1947 has almost the same capacity as the total capacity of the two boilers at Marion Generating Station. There are three rows of circular burners, horizontally fired, in the front furnace wall. There is a rotary feeder at the bottom of each precipitator hopper and the fly ash from four hoppers is discharged into a 6-in. line which goes down the side of the boiler to two dust nozzles, one 12 ft and

TABLE II—LABORATORY ANALYSIS OF FLY ASH

A typical analysis of fly ash is given below:

Analysis, %	
Silica	37.40
Aloxide	22.10
Ferric oxide	24.95
Calcium oxide	7.75
Magnesium oxide	1.08
Sulfuric anhydride	1.12
Phosphoric anhydride	0.55
Titanium oxide	1.50
Combustible	3.20
Density gr/cc = 2.63	
lb/cu ft = 82.87	

Sieve Analysis

Sieve No.	Passing	Retained	Per Cent
	...	60	1.70
	60	100	2.73
	100	200	5.80
	200	...	3.25
	325	...	86.52

Equivalents (Sieve Size vs. Microns)

Sieve	Microns*
60	250
80	177
100	149
140	105
170	88
200	74
230	62
270	53
325	44
400	37

* Micron—one-millionth part of a meter.

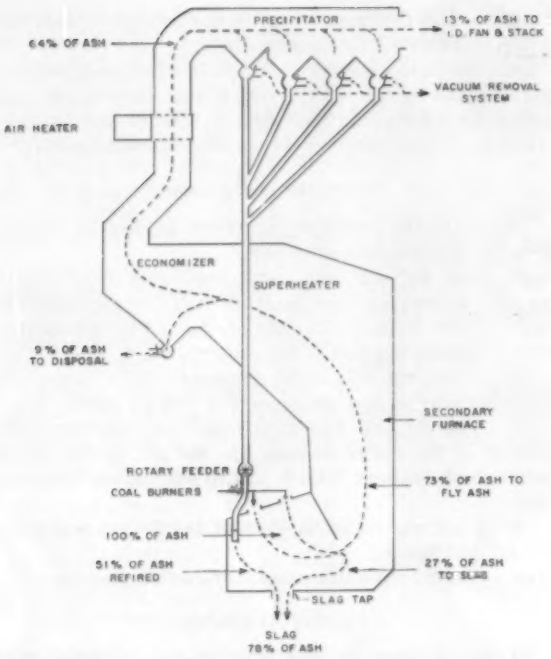


Fig. 10—A typical fly ash refiring system for the Marion Station is sketched in drawing above

the other 2 ft above the furnace floor. There are four such 6-in. lines, two on each side of the boiler, which continue down to the slag tank where the fly ash may be discharged if it is not being refired.

The installation of a rotary feeder at each precipitator hopper is a definite improvement over having the feeder in the 6-in. header, as in the Marion installation. The flow of fly ash can be controlled at its source so that no more dust will reach the nozzle than it can handle. Also, there can be no circulation of fly ash between precipitator hoppers through the dust lines as is possible at Marion.

The upper nozzles in the furnace side walls are the ones always used when refiring fly ash. These nozzles are located at points about one-third and two-thirds the distance between the burner wall and rear wall at the same elevation as the second row of burners. The nozzles are water-cooled, similar to the Marion nozzles, made of concentric tubes made elliptical, the outer tube originally having a diameter of 3 in. The movement of fly ash depends entirely on gravity.

The fly ash refiring system at Essex Generating Station has been remarkably free from operating problems. The fact that the fly ash downcomers extend to the slag tank allow the thorough flushing of these lines after each boiler outage or air preheater washing to fully remove any damp fly ash which may be present in the system. After each flushing the lines are, of course, allowed to thoroughly dry before any fly ash is fed through them.

Comparison of Marion and Essex Fly Ash Distribution

The following tabulation shows a close comparison of fly ash and slag distribution for the two stations. The Marion distribution is also shown on Fig. 10.

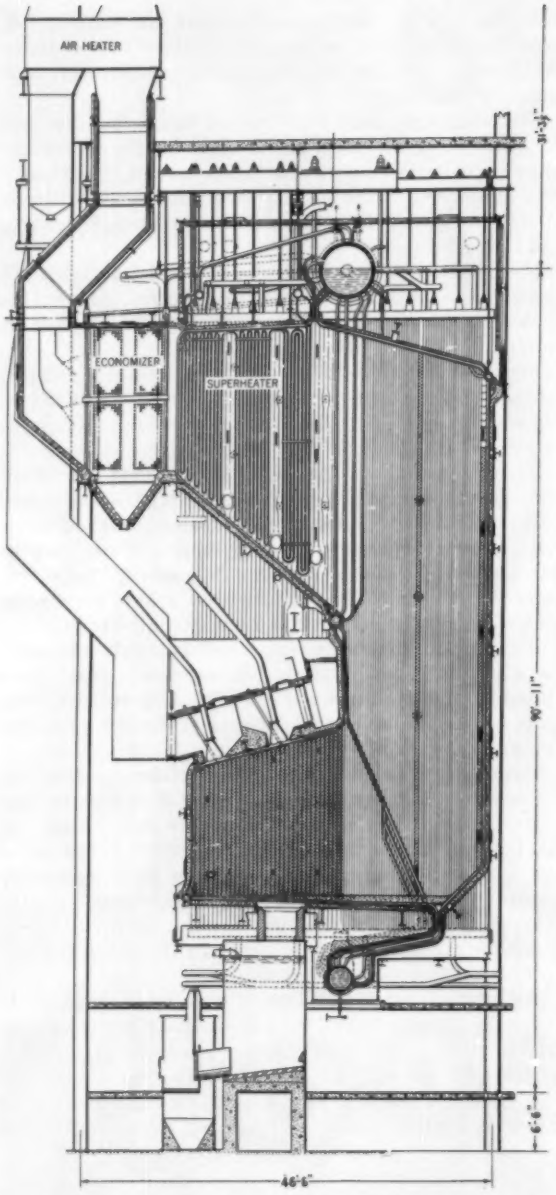
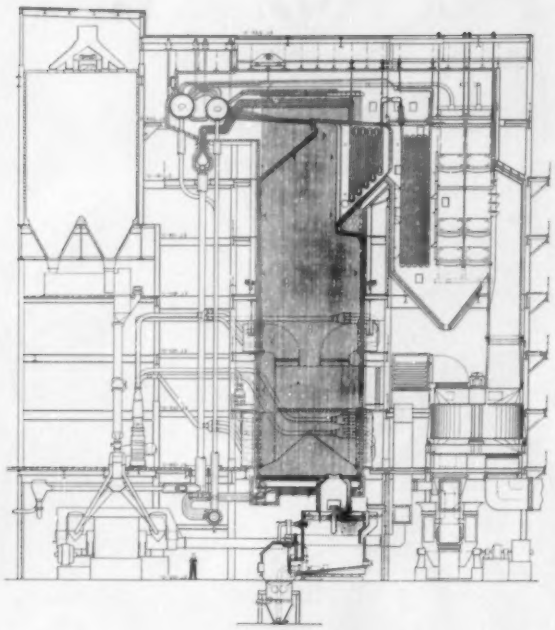


Fig. 11—Cross-sectional view of boiler at Marion gives indication of furnace layout

	Marion	Essex
Ash in the form of slag, %	27	25
Ash in the form of fly ash, %	73	75
Total ash, %	100	100
Fly ash to economizer, %	9	10
Fly ash to precipitator, %	64	65
Total fly ash, %	73	75
Fly ash refired, %	51	52
Fly ash to stack, %	13	13
Total fly ash from precipitator, %	64	65
Combustible in fly ash, %	4.8	1.36
Ash in coal, %	11.87	8.70
Weight of 1 cu yd of slag, tons	1.32	1.31
Weight of 1 cu yd of fly ash, tons	1.02	1.02



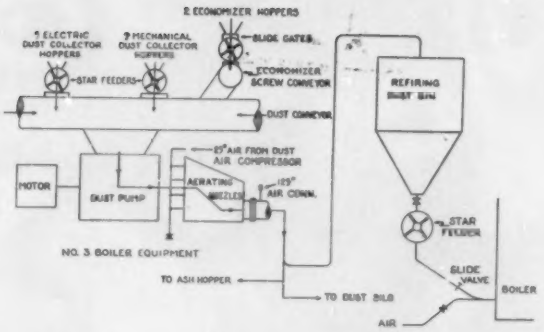


Fig. 12—Sewaren Station employs the above layout for its fly ash refiring system

←

Fig. 13—Cross-sectional view of Sewaren steam generator portrays tangential-firing furnace arrangement

Boiler Efficiency—With and Without Refiring Fly Ash

On June 13, 1956, tests were run at Kearny Generating Station on No. 8 Unit at full load to compare boiler efficiency with and without refiring fly ash. It was found that the heat absorbed, as determined by subtracting out all heat losses, was 12,124 Btu/lb, or 90.99 per cent when refiring dust.

When not refiring dust the heat absorbed was, for two runs, 12,102 Btu/lb, or 90.51 per cent, and 12,045 Btu/lb or 90.02 per cent.

This clearly shows that on a boiler of this type and size the refiring of dust improves the heat absorbed as much as 0.48 per cent to 0.97 per cent.

It should be noted that the per cent combustible in the fly ash at the precipitator outlet averaged 4.91 per cent on the run when refiring fly ash, and averaged 9.09 per cent when not refiring fly ash.

Investment Cost—Fly Ash Equipment

The investment cost for the boiler No. 3, Sewaren ash refiring equipment complete, was $29,000. In 1955 there were 165,000 tons of coal burned in this boiler. If we were to assume a 9 per cent carbon content in the fly ash, such a venture would pay for itself in a reasonable time. However, with a 3 per cent carbon content which occurs at Sewaren, it would appear that the investment would not be justified on a possible improvement in boiler efficiency alone. However, it does prove to be a sound means of transforming fly ash into disposable slag, all of which is sold.

Air Used to Transport Dust

At Sewaren refiring was done with various rates of air flow, transporting the dust in the boiler. Excessive amounts of air flow caused superheat temperature to rise from 5 degrees F to 15 degrees F. Best results were secured using approximately 33 cfm. at atmospheric pressure.

Schematic Diagram—Refiring System

In order to clarify the fly ash refiring system at Sewaren, Fig. 12 was drawn up so as to make it easier for the reader to orient himself with the equipment photographed.

Editor's Note:

The photographs referred to in the above comment on Fig. 12 are the ones shown as Fig. 6, the lead picture of the article, p. 40, and Figs. 7, 8 and 9 on pp. 43 and pp. 44.

SUMMARY AND CONCLUSIONS

(1) Whether refiring dust into a front-fired boiler or corner-fired boiler, the essentials of refiring should be followed in order to insure that the fly ash reaches its fusion point, melts, and flows to the slag hopper.

(2) Fly ash must be kept thoroughly dry in order to transport it from the hoppers to the refiring nozzle.

(3) All fly ash downcomer piping should be erected, if possible, at a slope of 60 degrees from the horizontal.

(4) Refiring nozzles work best when the face of the nozzle is parallel to the furnace floor.

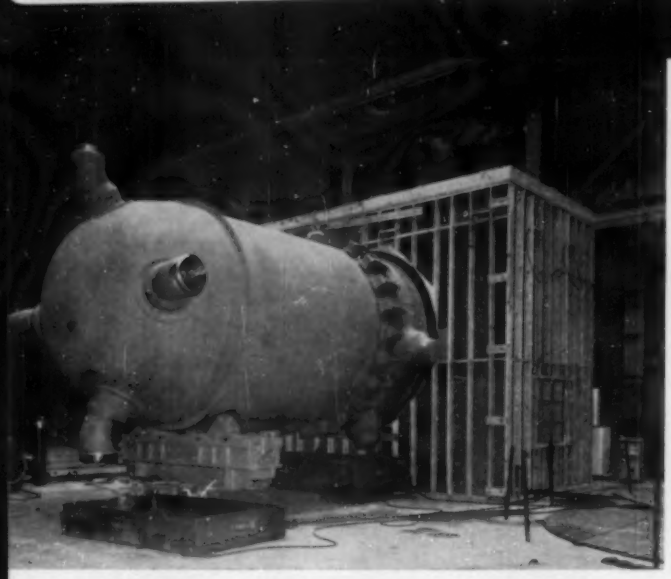
(5) Water-cooled nozzles fare better than others in front-fired boilers.

(6) No water cooling is necessary in tangential-fired boilers.

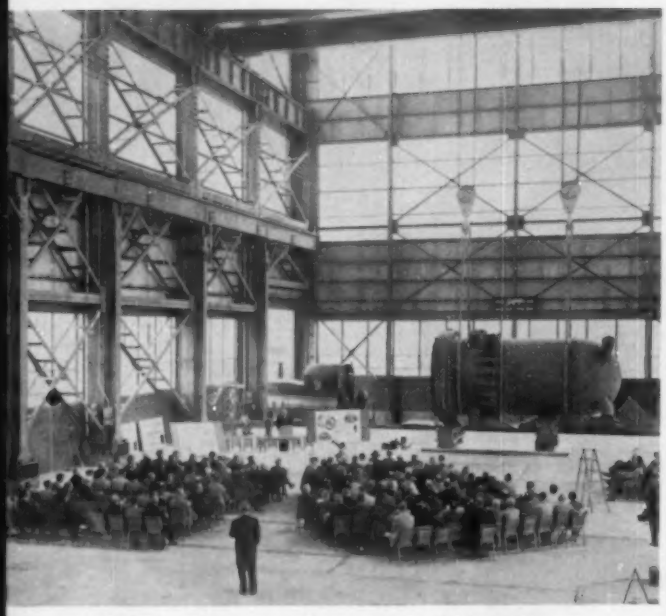
(7) Air for transporting dust costs money and should be kept to a minimum.

PWR Vessel en route from Chattanooga to Shippingport

The reactor vessel was built by Combustion Engineering for America's first full-scale nuclear power station which Westinghouse Electric Corp. has designed under contract with A.E.C. Duquesne Light Co. will operate the station. Further details in Oct. COMBUSTION, p. 59.

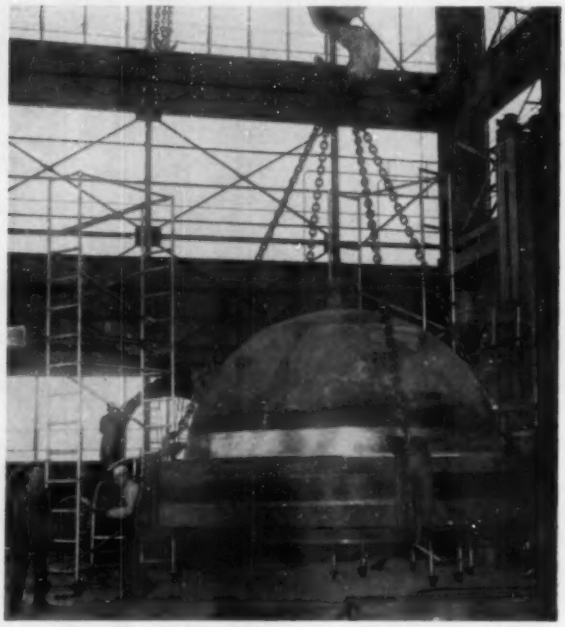


Vessel in cleaning room just prior to shipment



Combustion Engineering loads vessel on September 25

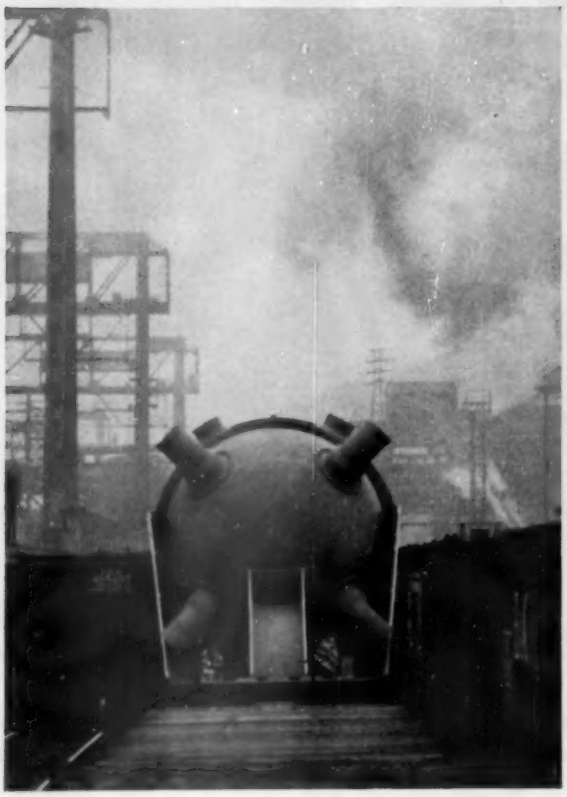
Size comparison of vessel shell and locomotive



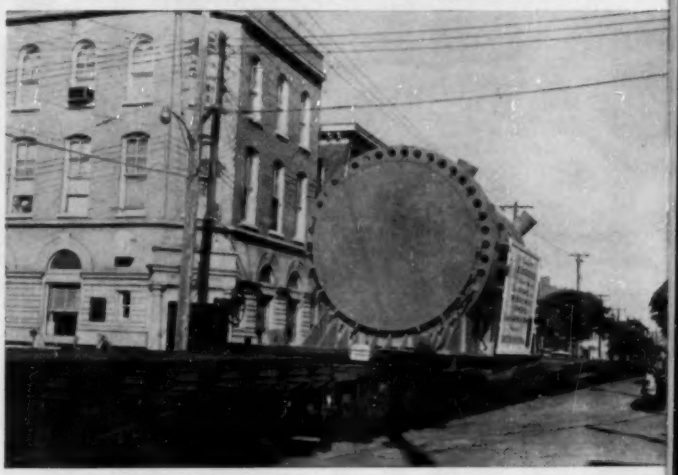
Shop view of 85-ton removable head

In the Susquehanna Valley on the Pennsylvania Railroad

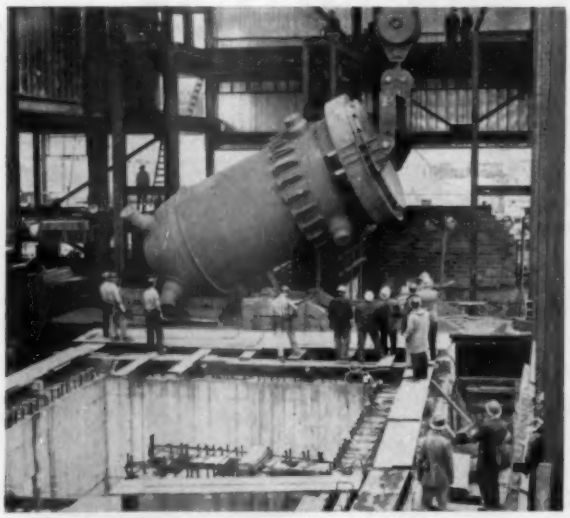
Nine-car special train crossing Susquehanna River on P.R.R. Rockville Bridge, world's longest stone-arch bridge



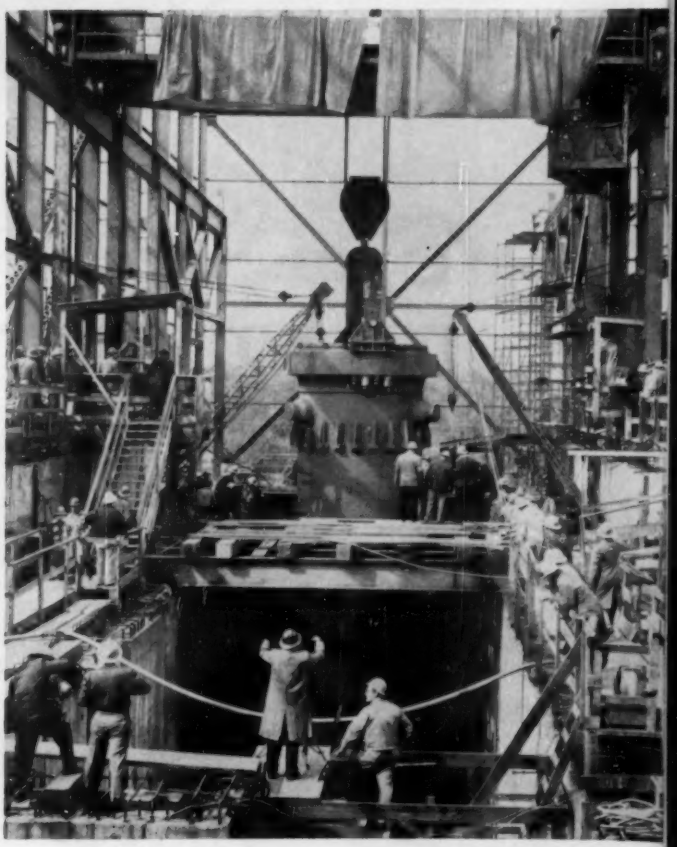
Early morning scene passing cars near Weirton, W. Va.



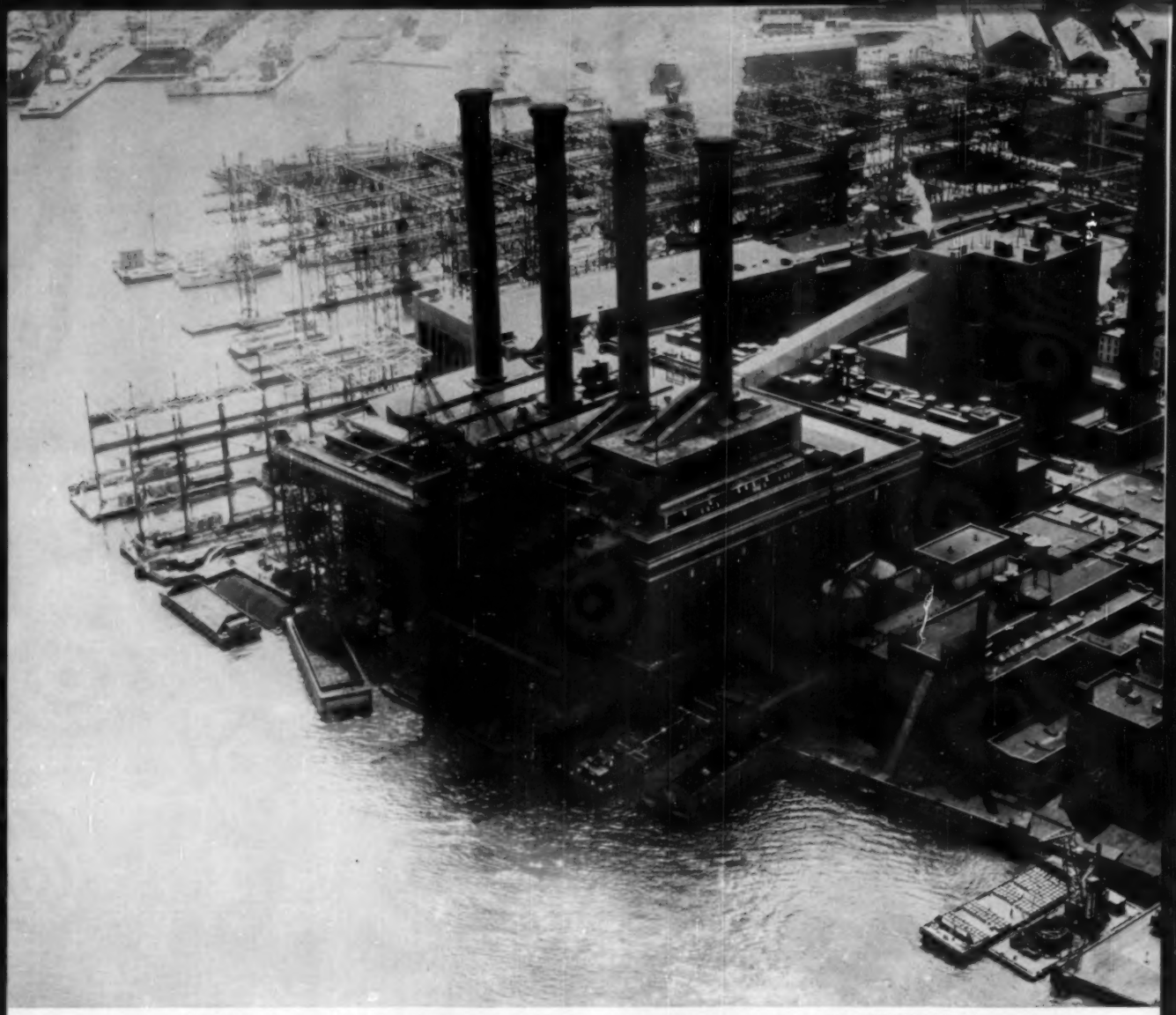
Passing through business district of Shippensburg, Pa.



Lifting Vessel shell from special car at Shippingport



Lowering shell into position on Oct. 10 at Shippingport



FOR LONG LIFE AND TOP EFFICIENCY THE EQUIPMENT IN THIS POWER PLANT IS CLEANED ONLY BY EXPERTS.

IT'S NOT WORTH THE CHANCE —CLEAN IT RIGHT

Equipment that operates at less than peak efficiency eats into your company profits. Chemical cleaning can help stop these losses—but only when it's done by experts. Unless you rely on experts, you're taking a chance with your men and valuable equipment.

Dowell engineers understand your cleaning problems and they have the *experience* needed to solve them. Thoroughly trained, they're backed by Dowell's 15 years' experience in removing troublesome scale deposits from virtually every kind of equipment in every kind of industry. They're aided, too, by a completely modern, fully staffed and excellently equipped *research* laboratory.

But, expert cleaning goes beyond keeping your equipment in top condition. Dowell considers the safety of company personnel at every step of the operation. The safest possible working procedures are worked out with your safety personnel.

Call Dowell. Our engineers are always ready to discuss chemical cleaning problems with you. There's no obligation. Or write Dowell Incorporated, Tulsa 1, Okla., Dept. K-25.

chemical cleaning service for industry **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

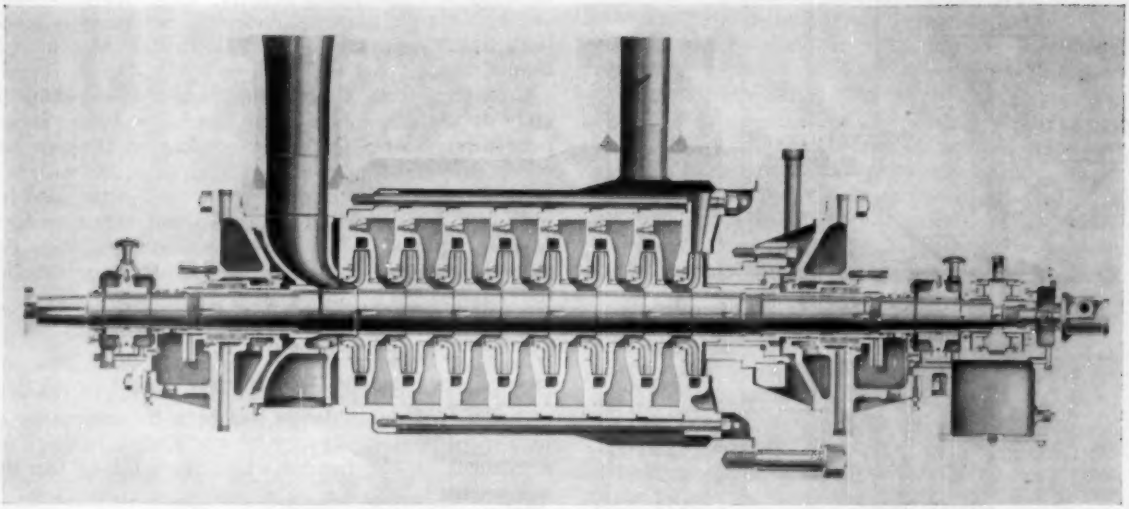


Fig. 1—High-pressure, double casing boiler feed pump with balancing device appears above

Steam Power Plant Trends and Their Effect on The Boiler Feed Pump—II

I. J. KARASSIK*

Worthington Corp.

The first article of this series presented a picture of the latest trends and developments in steam power plant design and of the effect they have on the design and application of centrifugal boiler feed pumps. The author now reviews the changes which have taken place in boiler feed pump design and application and considers the effect of these changes on the power plant itself.

THE choice between the axially split casing and the radially split casing design for boiler feed pumps is reasonably resolved at present with the former limited to discharge pressures of 1250 psi (in other words to application with 850 psi steam turbine units). This choice will be subject to re-examination at the higher speeds emerging today, since the reduced size of the casings would permit the limit to be moved up to possibly 1750 psi, at least for smaller capacity units.

The twin-volute versus the multiple vane diffuser design is still a controversial choice, at least among the pump manufacturers, with both schools of thought having their adherents. The same holds true of the two basic designs of axial thrust balance with four manufacturers using balancing devices (see Fig. 1) and two using opposed impellers. This distinction is one, however, of semantics rather than of fact, since both designs have high pressure differential running joints. The only real difference is that the balancing device design places this running joint at one of the pump extremities whereas the "opposed impellers" design has such joints in the middle portion of the pump. The major advantage claimed by the users of the balancing device is that the leakage through this running joint is capable of being measured and the design, therefore, permits a better check on pump behavior in service.

Another controversial issue is the number of stages used to generate a given pressure. However, power plant engineers have increased the range of their experience by contact with both "good" and "bad" practice. As a result, more attention is being paid to engineering features instead of "sales" features. An example of this is the greater trend toward short shaft spans and heavier shaft construction, or toward the use of single wearing rings where stainless alloys are used.

The entire subject of stuffing boxes is presently undergoing re-examination by both users and manufacturers. The major argument in favor of the elimination of stuffing box packing and using some other method of dealing with leakage from inside the pump is that repacking takes the pump temporarily out of service. The design of the pump internal parts and the metallurgy used for these parts have now progressed to the point that a high pressure boiler feed pump can run from 60,000 to 120,000 hours between complete overhauls. Impressive as such records are, the fact that a pump has to be shut down every 6 to 18 months for the purpose of repacking it, detracts considerably from this achievement in reliability. In other words, the search has been concentrated for some solution of the stuffing box problem which would give this part of the pump a life equal to the life of all internal pump parts.

* Assistant to Vice President and Consulting Engineer, Harrison Division.

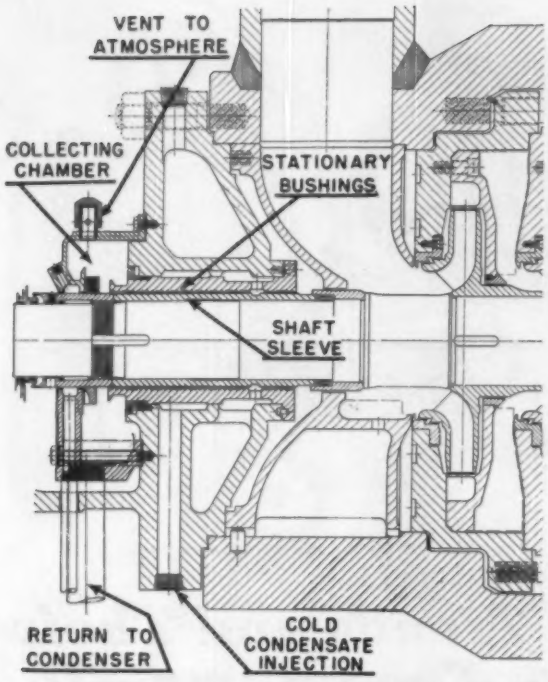


Fig. 2—The construction of one "packless" stuffing box now being used in some feed pumps follows above design

A great deal of interest has been directed to the possibility of utilizing mechanical seals. Results to date are still inconclusive, possibly because of the need of long time operation before acceptance is given. The difficulty lies in the fact that, essentially, the boiler feed pump does not lend itself too well to the use of mechanical seals. The greatest angularity of the shaft occurs at the seal location, precluding true parallelism of running and stationary faces. The presence of minute foreign particles, such as mill scale or oxides, introduces additional hazards.

There is an extremely interesting development in the high-pressure boiler feed pump stuffing box construction which involves the elimination of stuffing box packing and its replacement by a serrated labyrinth. Cold condensate is injected at the central portion of this labyrinth. A small portion of the injection water flows inwardly into the pump proper. The remainder flows out into a collecting chamber, from which it is piped back to the condenser. Fig. 2 illustrates the construction of such a "packless" stuffing box.

Cold condensate for the injection is taken immediately at the condensate pump discharge, before it has gone through any of the heaters located between the condensate and the boiler feed pumps. Units with this type of construction have now operated in the field for over two years and some thirty or more pumps have been so equipped. Everything indicates that this development will mark a milestone in the history of boiler feed pumps.

High-Speed Boiler Feed Pumps

One of the most significant developments in the field of boiler feed pump design has been the emergence of high-speed pumps. It may be worth while to dwell for a moment on the reasons which have led to this development.

The main purpose in running boiler feed pumps at speeds from 6000 to 9000 rpm is to develop higher heads per stage, reduce the number of stages required to develop a given pressure and reduce the overall size of the boiler feed pump. This reduction in size and in number of stages is not a matter of economic considerations but rather of relative reliability. A reduction in the number of stages results in a marked reduction in shaft span and, of course, a decrease in the shaft deflection. If the internal clearances are not reduced, the reduction in shaft deflection materially increases the reliability of the boiler feed pumping equipment. The smaller size of the pump carries with it another source of increased reliability, in that it reduces the area subject to internal pressures and therefore the stresses at the high-pressure pump casing joints.

As a matter of fact, the pressures to be developed by the boiler feed pumps intended to serve steam power plants operating at 3500 psi and above cannot be practically met with 3600 rpm pumps and, of necessity, such pumps must be designed to run at 6000 to 9000 rpm.

At this writing the high-speed boiler feed pump has reached the stage where it is no longer considered an experimental unit. In this connection, it may be interesting to examine the list of high-speed boiler feed pumps installed by or on order with the author's company (see Table I). The first unit was built for the

TABLE I—INSTALLATIONS OF HIGH-PRESSURE, HIGH-SPEED BOILER FEED PUMPS

Size and Stages	Customer	Location	No. Units	Lbs/Hr	Suct. Press., Psi	Disch. Press., Psi	Temp., °F.	Rpm	Driver
6″-4	Public Service of N. J.	Kearny Unit #8	1	610,000	285	2721	400	9000	Motor—hyd. cplg. and gear
5″-4	.....	.....	13	...	..	...	..	7130	Turbine
5″-4	.....	.....	13	...	..	...	..	7130	Turbine
8″-4	Public Service Elec. & Gas	Linden #1	4	1,050,000	237	2311	362	8250	Motor–gear hyd. cplg.
8″-4	Public Service Elec. & Gas	Lindens #2	3	1,000,000	431	2729	425	8440	Motor—gear hyd. cplg.
6″-4	International Paper Co.	Mobile, Ala.	3	565,000	605	1810	365	6500	Turbine
8″-4	Niagara Mohawk Power Co.	Huntley Station, Harriet, N. Y.	2	1,600,000	153	2720	270	7000	Turbine
8″-6	Cleveland Electric Illuminating Co.	Cleveland, Ohio	3	1,026,000	289	4803	340	7570	2 Turbines, 1 motor, gear and hyd. cplg.
8″-5	Metropolitan Edison	Portland #1	2	658,000	263	3570	364	6800	Motor, gear and hyd. cplg.
6″-4	Tokyo Electric	Tokyo	4	480,000	163	2898	328	8500	Motor and gear

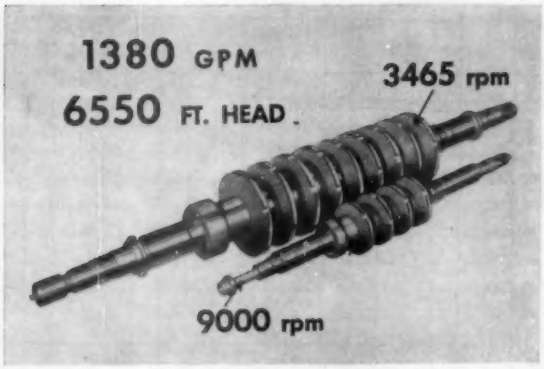


Fig. 3—The size advantages enjoyed by high-speed boiler feed pumps shows in view of a 9000 and 3500 rpm rotors

Public Service Electric and Gas Co. of New Jersey and installed in the Kearny plant extension for units Nos. 7 and 8. This pump was designed to handle 592,500 lbs per hr of 400 F feedwater against a discharge pressure of 2720 psig. It is a four-stage pump designed to operate at 9000 rpm. In order to utilize the same type of drivers as for the remaining four conventional 3500 rpm pumps in this station, this high-speed boiler feed pump is driven by a 3000 hp, 3570 rpm motor through a hydraulic coupling and a step-up gear. After initial operation, this pump underwent certain desired mechanical design modifications and was returned to normal service at the Kearny plant where it has been operating since late 1954.

Since then, a total of 21 additional high-speed pumps have been ordered for service in electric steam generating power plants.

In addition, 26 high-speed steam turbine driven high-pressure boiler feed pumps have been ordered from the author's company by the U. S. Navy for service on the latest type of aircraft carrier (see Fig. 4).

Service Conditions and Application Problems

Once the size of a given unit and its operating pressure is established, the selection of pump capacities and pressures is a reasonably resolved problem. Experience with high-pressure construction and modern material selection indicates that the large margins over the boiler capacity formerly incorporated in pump ratings are not necessary. A margin of as little as 8 per cent over the maximum boiler rating is now considered sufficient, with 4 per cent of the margin to take care of swings and 4 per cent to take care of wear.

The selection of the number of pumps for a given installation is still a controversial problem in some ranges, some power plant designers using two half-capacity operating pumps and a third as a standby regardless of the size of the installation. The optimum arrangement, however, appears to be two full capacity pumps (one running, one standby), for units of up to 80,000 kw. For 100,000 kw and above, three half-capacity pumps are preferable. There is the possible exception for future installations of high-speed turbine driven pumps, where the high cost of the driver (almost independently of size) makes the full capacity pump more economical even for large units.

The choice between closed and open feedwater cycles does not depend in any way on the boiler feed pumps themselves, and is based strictly on the degree of dependence which the power plant designer is willing to place upon satisfactory deaeration in the condenser hotwell. The choice has some effect on pump operation, however, since the closed cycle eliminates NPSH problems due to the fact that the condensate pump discharge pressure can be selected greatly in excess of the sum of the vapor pressure at the feed pump and of the minimum required NPSH. At the same time, the lack of storage at the feed pump suction makes it imperative to protect the feed pumps against interruption of supply from the condensate pumps and protective controls are mandatory.

The problem of the location of the feed pump in the cycle had been almost resolved, with a trend away from handling feedwater at temperatures above 400 F. In other words, several of the closed heaters were being located downstream of the boiler feed pump itself. The disadvantage of handling higher temperature feedwater stemmed essentially from the resulting increase in power consumption and, in the past, from concern over the ability of the existing designs to operate properly under these higher temperatures. This last argument is no longer as important today and the higher pumping costs are frequently outweighed by the savings in heater costs and in the cost of their maintenance.

The strongest impetus to the possibility of splitting the work between a primary and a secondary feed pump in series, with closed heaters located between these two has come from the superpressure power plant, as heaters suitable for 5500 psi and higher simply were not available at first. All the same, the correct solution to the ultimate best location of the feed pump in the cycle range would seem to lie in the improvement of heater design for different cycle positions rather than in the shifting of the problem on to the boiler feed pump.

But more important changes are in the making with regards to the boiler feed pump drives. Steam turbines, gas turbines, magnetic drives, direct drive from the main turbine are all being thoroughly investigated.

Variable Speed Operation of Boiler Feed Pumps

The argument between the proponents of variable speed drive with hydraulic couplings or magnetic drives

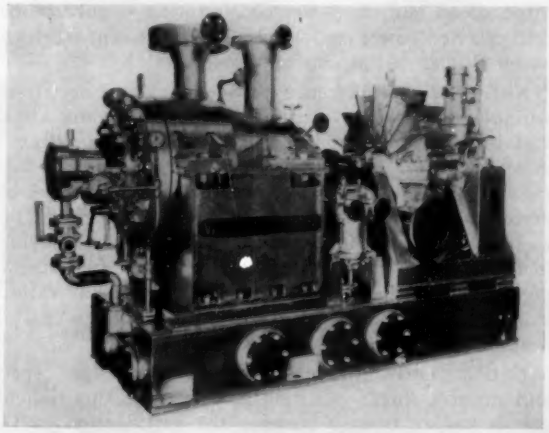


Fig. 4—High-speed turbine-driven, four-stage boiler feed pump to serve Aircraft Carriers CVA-60 and CVA-62

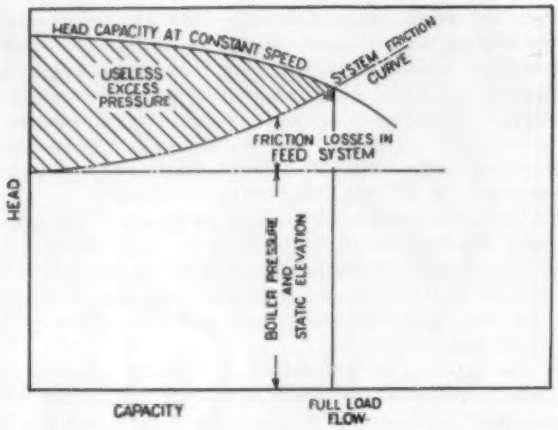
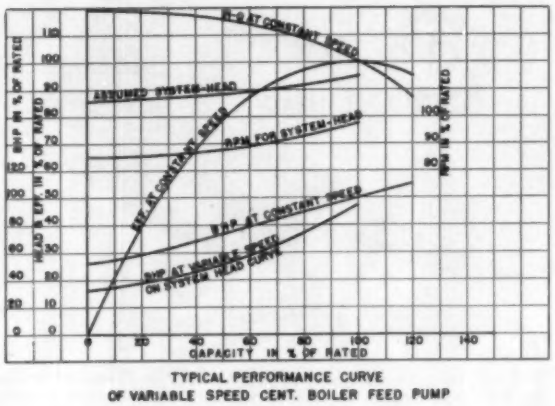


Fig. 5—Relationship between pressure generated by centrifugal pump and pressure required to feed a boiler shows in the hydraulic characteristics of a boiler feed system


H-Q AT CONSTANT SPEED
ASSUMED SYSTEM-HEAD
RPM FOR SYSTEM-HEAD
BHP AT CONSTANT SPEED
BHP AT VARIABLE SPEED ON SYSTEM HEAD CURVE
HEAD IN FT. IN % OF RATED
BHP IN % OF RATED
RPM IN % OF RATED
CAPACITY IN % OF RATED

TYPICAL PERFORMANCE CURVE OF VARIABLE SPEED CENT. BOILER FEED PUMP

Fig. 6—Typical performance curve of a boiler feed pump is expressed here in terms of percentage of its design condition. This applies to a variable speed design

and advocates of the direct connected constant speed motor drive still rages. To properly understand the basis of the argument, it is necessary to visualize the relation between the pressure generated by a centrifugal pump and the pressure required to feed the boiler. This relation is illustrated on Fig. 5. The pressure generated by a centrifuga' pump at constant speed increases with a decrease in capacity, the rise in pressure between full load flow and shut-off conditions ranging anywhere from 10 to 25 per cent. On the other hand, the pressure required to feed the boiler has the general characteristics of a system-head curve, decreasing appreciably with a reduction in flow. The difference between the pressure generated by the pump and the pressure required to feed the boiler can be considered as useless and must be absorbed by throttling with a feedwater regulator or eliminated by variable speed operation. Obviously, when the boiler feed pump is operated at variable speed, its power consumption is reduced appreciably. Fig. 6 is a typical performance curve of a boiler feed pump expressed in terms of percentage of its design conditions. It will be noted, for instance, that when the pump is operated at 60 per cent of its rated conditions, the pump need run at only 89 per cent of its rated speed and its power consumption is only 58 per cent of rated power compared with 79 per cent when the pump is operated at constant speed.

Not all of the difference between constant speed and variable speed power consumption is a net gain, as the variable speed mechanism (be it a hydraulic coupling or a magnetic drive) has an efficiency which decreases with speed reduction, or slip. Nevertheless, an appreciable saving in power consumption is available at part load operation. In order to determine whether these savings justify the purchase of a variable speed mechanism, predictions on the number of operating hours at various loads must be made and the resulting savings capitalized and compared to the cost of the drive.

Until recently, the choice between constant speed and variable speed operation had been a rather difficult one to make, mainly because the justification of the variable speed equipment is so intimately tied up with the principles followed in the evaluation of the savings and these principles tend to reflect the personal preferences of the engineer who is making the evaluation. No very marked trend change had taken place between 1950 and 1955, with about 25 to 30 per cent of the installations for 1250 psi throttle pressure and above going to hydraulic coupling drive.

The growth of operating pressures, however, will have a very marked effect on the frequency of hydraulic coupling or magnetic drive applications. One of the main reasons for this predicted trend is the growth in the size of the drivers. The savings remain proportional to the size of the driver while the initial cost, expressed in dollars per horsepower, definitely decreases with size. Thus, for larger motors, there is greater justification to purchase a variable speed component.

While magnetic drives had not been a serious competitor of the hydraulic coupling until recently, this was mainly because they were not available at the 3600 rpm speed in the sizes encountered in boiler feed pump application. With the trend to higher speeds and, therefore with the emergence of 1800 rpm motors coupled to the pumps by means of step-up gears, the magnetic drive will definitely come into wider use.

Steam Turbine Drive

After an absence of over 25 years, the steam turbine driven boiler feed pump is coming back to large steam electric generating stations. During that time, except for a few isolated cases where a turbine driven pump may have been used for standby service, the turbine had been completely abandoned as a potential boiler feed pump driver. But by 1955, several utilities had returned to the steam turbine and more are expected to follow suit.

What are, then, the advantages which can be derived from this type of drive? We may list a few of these:

1. Increase in plant capability by the elimination of the auxiliary power required by the boiler feed pump. The net increase in capability is, of course, a function of the plant operating pressure. For instance, this increase will be of the order of 2 per cent for an 1800 psi unit and as much as 4 per cent for a 3500 psi unit.

2. Driver speed can be matched ideally to the optimum pump speed. Use of the turbine drive eliminates the 3600 rpm synchronous top limitation on the pump speed without the necessity of interposing a gear between the driver and the pump.

3. Variable speed operation permits power savings at reduced loads without the necessity of interposing a hydraulic coupling between the pump and its driver. It permits the elimination of the feedwater regulator with its attendant investment and maintenance costs and its losses of power.

4. Less excess margin need be included in the pump capacity, as effect of pump wear on the net capacity can be compensated by a slight speeding up of the turbine.

5. Improvement in cycle efficiency can be obtained by the proper utilization of the exhaust steam in feedwater heaters.

Lest we underestimate the importance of some of these advantages, let us examine in detail the effect of increasing plant capability. If we assume a 200,000 kw unit which requires a 7000 hp boiler feed pump, the elimination of the electric motor drives will add some 5600 kilowatts to the net available capability of the unit. Depending upon a number of factors, each incremental kilowatt can be evaluated at from $60 to $100, so that the increased capability can be credited at $335,000 to $560,000. Some of this money will of course be spent on the difference in the initial cost of turbines and electric motors.

Let us assume that two full size turbine driven pumps are being considered in comparison with three half-capacity motor driven pumps. The turbines may be worth about $180,000 each to which must be added the cost of steam piping and valves. This brings the total to about $450,000. Three 3500 hp motors are worth approximately $210,000 and the added cost of starters and other electrical appurtenances may bring the total to $300,000. Actually two full-capacity pumps will cost less than three half-capacity pumps in this range of sizes, but we may even neglect this difference. In so far as the drivers themselves are concerned, therefore, the turbine drive will add $150,000 to the initial station costs. This increase is so much less than the added value of the increased capability that we need not bring the remaining factors into the picture to justify the turbine drive.

Of course, these turbines will not take steam directly from the boiler drum or steam generator, since the high pressures and temperatures would make this practice prohibitive. Instead, the boiler feed pump turbines will be supplied with steam either from a bleed stage of the main turbine or from the cold reheat line.

At the present writing, it is safe to predict that the future of the steam turbine drives for boiler feed service is bright and that the next few years will see a great number of such installations.

Gas Turbine Drive

Studies similar to those carried on steam turbine drive were suggested to us by several utilities, late in 1953, for the gas turbine drive.

At that time, gas turbines capable of switching from oil to gas and back again without being brought to rest were not available and the study presented mainly an academic interest. Since then, changes in design have made the gas turbine a more available type of unit and have removed a great number of the doubts which existed then as to the wisdom of applying it to this service.

Essentially, the gas turbine possesses all of the advantages of the steam turbine plus that of improving the overall heat rate to a more appreciable degree. However, all of the improvements which are being made in this equipment will probably result in its being applied to topping service as a generator drive rather than to drive the feed pumps. This subject has been treated in some detail in the first article of this series.

Single Full-Capacity Pump per Unit

Several installations have been ordered where a single turbine driven full-capacity boiler feed pump is used, with no spare pump whatsoever. A discussion of the merits of such an installation is obviously a very controversial subject. Many of the arguments which will be mentioned in connection with driving the boiler feed pump from the main turbo-generator apply here—and possibly even more forcibly. When the pump is driven from an extension of the main unit, it is absolutely necessary to have a separate motor-driven part-capacity pump for the start-up. This part-capacity pump can also serve the function of emergency standby, even though the main unit would have to run at some reduced load during the outage of the main feed pump or of the hydraulic coupling serving it. But if the main feed pump is driven by a separate steam turbine, there is no need of a motor driven start-up pump capable of developing the full pressure. The tendency, therefore (as exemplified in the several installation we have referred to), is to eliminate the motor driven part-capacity standby pump.

In evaluating the merits of such an arrangement, the following factors must be weighed:

1. the cost of a spare pump, its driver, controls and piping

2. the available reserve kilowatt margin of the system served by the unit under consideration

3. the cost of replacement power during outage—assuming that the kilowatts lost may have to be replaced by kilowatts generated at the cost of the highest heat rate in the system served by this unit.

Main Steam Turbine Drive

There has recently arisen a considerable amount of speculation over the possibility of driving a full capacity boiler feed pump directly from the main turbo-generator. A hydraulic coupling would be used between a 3500 rpm pump and the shaft extension of the generator, so that variable speed operation can be obtained and so that the boiler feed pump can be disconnected from the main unit in case of emergency. One or more separate part-capacity boiler feed pumps, driven by electric motors would be used for start-up and for emergency standby. Two 325,000 kw units have been ordered with such a boiler feeding arrangement and several more are contemplated.

In principle, the idea has great merit. The main advantage resulting from this arrangement resides in the savings which can be made by the elimination of an independent drive. Not only does it become unnecessary to acquire a separate motor driver, but the net

capability of the generator is not reduced by the power required to drive the feed pump.

There is no question, of course, that the intrinsic reliability of the modern boiler feed pump has reached levels equal to or even exceeding those of the boiler or the main turbine themselves. It is quite normal to expect from 60,000 to 80,000 hours of operation before overhaul of a high-pressure boiler feed pump is necessary and cases exceeding 100,000 hours are on record.

There are, however, some problems to be considered in applying this type of drive. In the first place, unless step-up gears are used, the boiler feed pumps will be limited to a speed of 3500 rpm. This will definitely place a limit to the pressures for which such an arrangement can be made applicable. In addition, it will make the discharge head bolting of the pump subject to much greater stresses by virtue of the larger pump barrel dimensions (which will grow further, since full-capacity units would be involved, ranging to 6000).

There are, furthermore, certain operating hazards which confront the boiler feed pump and which have no equivalent counterpart in the case of the boiler or steam turbine. One of these hazards, and perhaps the most important one, is the possibility of foreign matter being introduced into the pump. This foreign matter may consist of mill scale or loose particles of the brittle black oxide. It generally finds its way into the pump during the early part of its operating life, frequently during the first few weeks of operation. The catastrophic effect of such an occurrence is too well known to power plant operators to require further discussion.

Probably the most thorny problem would be a psychological one. The interruption of service due to any sort of failure of the pump arising from circumstances beyond the manufacturer's control would place the manufacturer under terrific pressure to get the unit back into service. At the same time, the price the manufacturer receives for his pumps is such a small fraction of the cost of the main unit, that he is unable to adopt as heroic measures in event of an emergency as in the case of the main turbine manufacturer. On the other hand, the operating personnel, who may accept a shutdown of up to eight weeks in some cases to correct main turbine difficulties, will become restive after three or four days' shutdown of a pump.

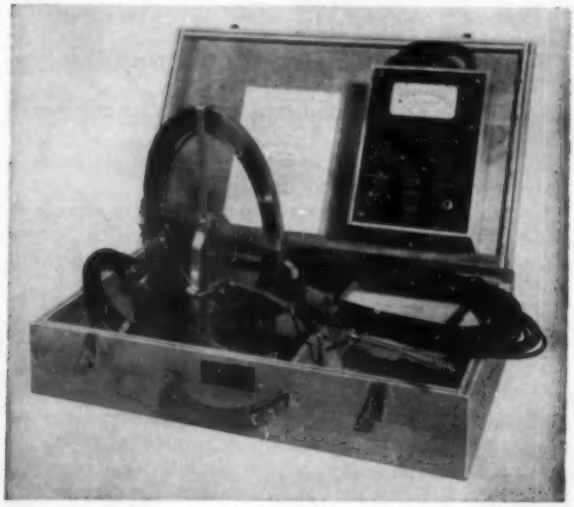
A more practical situation may exist in the case of cross-compound turbines, both operating at 3600 rpm. In such a case, two separate half-capacity boiler feed pumps may be installed. Shutdown of one pump would not reduce the station load since a half-capacity motor-driven spare pump would be installed.

Conclusions

The problems presented by the design and application of boiler feed pumps in the modern high pressure steam-electric generating station are varied, ever-changing and extremely absorbing. Because of the growing importance of this equipment, it is necessary for boiler feed pump manufacturers and users alike to accumulate as much knowledge as possible of all the power plant practices and problems which may affect boiler feed pump operation.

It is also necessary to adopt a reasonably conservative approach to design as reliability and freedom from excessive maintenance are the first requisites of a successful boiler feed pump. And departures from tried and proved practice can only be made after thorough analysis of the effects such departures may have on the reliability of the equipment.

In this field as in many others, it is useful to stop sometimes and take stock of the progress which has and is taking place. These articles were intended to serve such a purpose. The author hopes that by the time it is found advisable to bring this picture up to date, the directions taken by steam power plant developments will not be found to differ too widely from those predicted



STOP **UNEXPECTED BOILER TUBE FAILURES**

This completely new and improved model TURNER SCALE THICKNESS INDICATOR not only reads scale directly in thousandths of an inch, it is invaluable in locating pitted and eroded tubes prior to their failure, thus eliminating costly shutdowns. Write for technical data and information today.

HASKINS-TURNER COMPANY
1617 THIRD STREET JACKSON, MICHIGAN

COMBUSTION ENGINEERING

A Reference Book on Fuel and Steam Generation

Edited by OTTO de LORENZI

COMBUSTION ENGINEERING is probably the most comprehensive technical book ever published by an equipment manufacturer. Its 30-odd chapters and appendix run to well over a thousand pages and include more than 400 illustrations and about 80 tables. It is designed for the use of both engineering students and practicing engineers.

Profusely Illustrated 1042 Pages Size 6¼ x 9¼ Price $7.50*

Book Dept., COMBUSTION PUBLISHING COMPANY, INC.
200 Madison Avenue, New York 16, N. Y.

Quality Measurements by Flame Photometer*

The persistently perplexing problems of deposition in steam turbines require greater refinements in determining allowable limits of steam purity. The development of the sodium tracer technique for such determinations coupled with the use of flame photometry for sensitive detection of the sodium offers, in the author's opinion, an accurate means of measurement.

By J. K. RICE

Cyrus Wm. Rice & Company

STEAM purity testing techniques have evolved through the years from the simple throttling calorimeter to the measurement of specific conductance, first as collected, later, following mechanical degassing devices, and recently following acid regenerated cation exchangers. This evolution has been necessary both to keep pace with the improvements in separating equipment in steam drums and equally to attempt to solve many perplexing problems of deposition in turbines.

The use of specific conductances to measure the amount of boiler water entrained in steam is based on the fact that the salts dissolved in the boiler water so entrained contribute to the specific conductances of the steam. It was early recognized that CO_2 and NH_3 dissolved in the condensed steam and contributed to the conductivity. The conductance of these substances were computed and corrections made in the measured conductance of the samples. Mechanical degassing devices of many kinds were developed. In the last several years the use of volatile neutralizing amines in steam systems has brought on the development of an ion exchange device the primary purpose of which is to remove simply and continuously the effect of the amines and of ammonia. Reboiling of the effluent from an acid regenerated ion exchange column attempts to remove the effect of the CO_2 and to leave an effluent the conductance of which is a true measure of the dissolved solids in the steam.

Throughout all the evolution of specific conductance techniques one is confronted with countless instances where deposits of boiler salts were found in turbines when no such deposits should have occurred based on the conductance measurements of the steam. This apparently contradictory situation can only mean that the critical or depositing amount of boiler water solids entrained in the steam is less than the minimum accurately detectable by conductance measurements. This also means that the amount of boiler water solids in the non-depositing steam is less yet and certainly far, far less than supposed on the basis of conductance measurements.

The foregoing state of affairs led many concerned with steam purity problems to seriously question the validity of results obtained by electrical conductance and to investigate other more sensitive means of determining boiler water carryover.

Searching for Greater Sensitivity

The ideal method of determining the amount of boiler water carryover in steam is to determine the concentration of some particular substance in the steam that can be present in the steam only by the entrainment of boiler water. This ideal condition requires that the

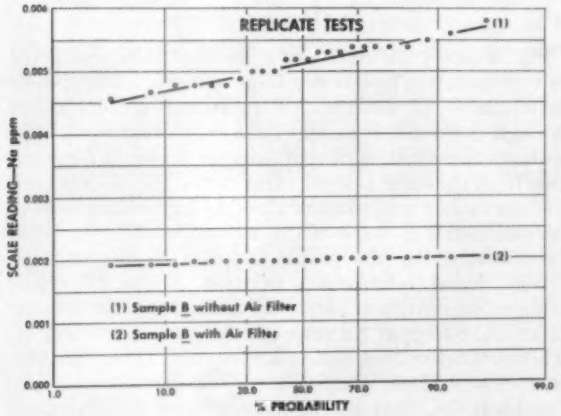


Fig. 1—Lack of reproducibility of analyses was a serious drawback in use of flame photometry for sodium measurements until an air filter was employed on air stream induced into the flame. Curve (1) shows spread of results with no filter and Curve (2) reliability with filter.

* Presented at the Seventeenth Annual Water Conference of the Engineers Society of Western Pennsylvania, Pittsburgh, Pa., October 1956.

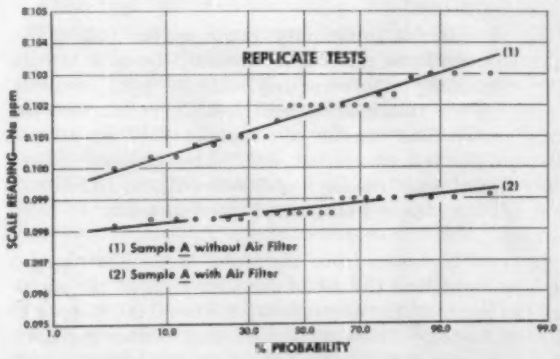


Fig. 2—Similar test procedure as that in Fig. 1 was employed above except sodium concentration here was 0.097 ppm instead of 0.0003 ppm as in Fig. 1.

substance is not preferentially soluble in the steam and that therefore the ratio of the concentration in the steam to that in the boiler water is the ratio of the boiler water entrained in the steam to the total steam.

There are three fortunately coincident conditions that led directly to the choice of sodium as the constituent most suited to the ideal conditions expressed in the foregoing:

(1) With the exception of silicon dioxide and iron oxide, the major depositing materials in turbines are sodium salts

(2 The highest concentration of a single element in the usual boiler water is sodium.

(3) The use of a flame photometer allows detection of as little as 0.0002 ppm of sodium in dilute solution under ideal conditions.

The paper by E. E. Coulter and T. M. Campbell presented at the Annual Meeting of the ASTM in Atlantic City, June 1956,[1] is one of the first to present concrete evidence based on sodium determinations that specific conductance measurements for steam purity are increasingly inaccurate below 5.0 mmhos and practically invalid below 1.0 mmho. The authors presented data obtained both by radioactive tracer measurements using P^{32} as well as by sodium tracer measurements using a flame photometer.

The data to follow will corroborate that presented by Coulter and Campbell and will extend the area of comparison of sodium tracer technique to include conductance measurements following an acid regenerated ion exchange sample preparation device. The comparative data presented was obtained entirely from measurements on operating boilers.

Sodium Tracer Technique

One of the earliest encountered difficulties with the sodium tracer technique was the lack of reproducibility of the analyses because of contamination. In the author's laboratory it was determined that careful sample manipulation reduced the contamination but that the dispersion of the data on replicate runs seemed most directly related to atmospheric conditions at the time of analysis. The major source of apparent contamination was not in the instrument or sample manipulation but in the air induced into the flame. This line of attack led naturally to a trial and error selection of air filters that could be employed to filter all of the air induced into the flame housing by the chimney effect of the oxy-hydrogen flame.

Fig. 1 shows a probability graph of the results obtained on replicate sodium determinations of a sample (B) containing approximately 0.0003 ppm sodium. Curve (1) was obtained without and Curve (2) with the use of an air filter capable of removing 99.97 per cent of all particles 0.3 micron in size. The ordinate represents actual scale readings obtained without the deduction of the flame background corresponding to zero sodium.

It is to be noted from the slope of the distribution lines in Fig. 1 that the use of the filter reduced the standard deviation of the determination from 0.00034 ppm to 0.000016 ppm. More significant than reducing dispersion, however, is the reduction in the mean of the scale readings from 0.0052 ppm to 0.0020 ppm. The net reduction of 0.0032 ppm represents the level of air-borne contamination which in this instance was equivalent to ten times the actual amount of sodium in the sample. Records kept of this difference with and without the filter showed that the air-borne contamination varies from an equivalent sample sodium concentration of 0.002 ppm to 0.020 ppm depending mainly on the relative humidity in the air in the laboratory and to a lesser extent on the general activity in the laboratory. As would be expected a low relative humidity of 30–50 per cent causes the maximum air-borne contamination while a high relative humidity of 50–70 per cent causes the least air-borne contamination.

Fig. 2 is similar to Fig. 1 except that the sodium concentration of the sample (A) is 0.097 ppm instead of 0.0003 ppm. Here again the effect of the air filter is quite noticeable and caused a similar reduction of 0.003 ppm Na from contamination.

An analysis of the information shown leads to two tentative conclusions:

(1) With maximum amplification of the Beckman DU photomultiplier and using an O_2-H_2 flame with the air filter described, the standard deviation of steam samples containing less than 0.007 ppm Na is 0.00016 ppm and is mostly due to the inability to read the instrument closer than 0.020 per cent of full scale.

(2) Under the same conditions as above but at concentrations greater than 0.007 ppm Na, the standard deviation increases with increasing concentration and is approximately 0.34 per cent of the amount present. This is apparently the result of a fluctuation in the sample aspiration rate.

With the use of the air filter the problem of reproducibility of sodium determinations in so far as the instrumental technique was concerned was apparently solved and the extreme sensitivity of the method established. This allowed confidence in the analytical results obtained and, therefore, made possible effective use of the analytical data obtained in developing sample collection procedures. All of the laboratory tests to establish precision for the method would be of only academic interest if the results were not useful in the solution of steam purity problems.

Tests on Operating Boilers

Fig. 3 shows the results of a series of tests conducted on two operating boilers in a large refinery. The specific conductance of samples of saturated steam passed through a Straub degasser is shown plotted versus the sodium concentration of spot samples drawn at the same time from the same source. One of the two boilers periodically carried over to a considerable degree obvious from the magnitude of some of the sodium tests. The point demonstrated by the graph, however, is the approximately linear relationship between conductivity and sodium concentration above 5.0 mmhos specific conductance and 0.50 ppm Na respectively. The non-linear relationship below these points is obvious. These data support closely those presented by Messrs. Coulter and Campbell, i.e., that specific conductance measurements become an increasingly inaccurate measurement of solids in steam at conductivities less than 5.0 mmhos. The average quality of steam produced at this plant from a number of boilers, some of which carry over more than

[1] Editor's Note: Abstracted in Combustion, July issue, p. 63.

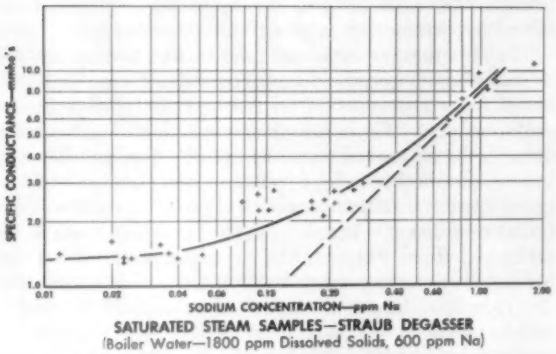

SPECIFIC CONDUCTANCE—mmho's
SODIUM CONCENTRATION—ppm Na
SATURATED STEAM SAMPLES—STRAUB DEGASSER
(Boiler Water—1800 ppm Dissolved Solids, 600 ppm Na)

Fig. 3—Curve shows comparison of specific conductance readings on a saturated steam sample drawn through a Straub degasser against sodium determinations. Note non-linear relationship below 5.0 mmho's specific conductance and 0.5 ppm Na.

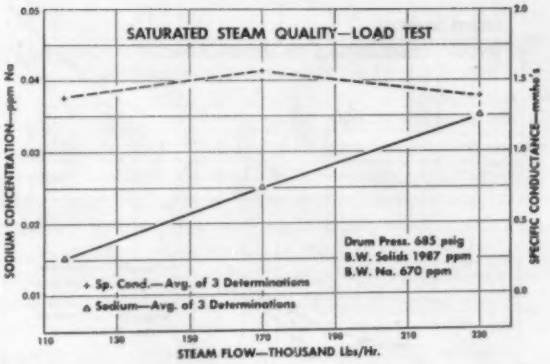


Fig. 4.—A comparison of specific conductance readings on a saturated steam sample taken as in Fig. 3 for a loaded boiler against sodium determinations at the same boiler are shown for three specific load points.

others, is 0.20 ppm. Turbines operating on this steam foul rapidly with soluble deposits and require washing every several months. It is plain that the sodium concentration of 0.20 ppm which causes heavy fouling is in the range where specific conductance is becoming unreliable.

The study of the causes of carryover from an operating boiler is aided by a study of the effect of load on steam quality while all other variables are held constant. Fig. 4 illustrates the results obtained by such a load test. The boiler was operated for six to eight hours under each of the loads indicated. During the steady load conditions saturated steam samples were continuously drawn, passed through a Straub degasser and the specific conductance measured. At the same time three samples of saturated steam were collected in succession and later analyzed for Na. The average of the results by each method is shown versus the load condition. It is readily apparent that the sodium measurements show the decrease in steam quality that occurs with increase in load while the specific conductance measurements do not.

Ion Exchange Degassing Method

It was mentioned previously that one of the most recent developments in sample degassing devices is to pass the cooled sample through an acid-regenerated cation exchange bed. This process removes ammonia from solution by exchanging it for hydrogen ion. At the same time all other cations including sodium and potassium are so exchanged. The effluent from the exchange bed is then passed either through a reboiler to a conductivity cell or direct to the conductivity cell depending on the amount of CO_2 present. The specific conductance that is measured is presumably only that of the dilute acids present, H_2SO_4, HCl, H_3PO_4. These acids, of course, originated as their sodium salts in boiler water carried over into the steam. It is well to note, however, that any sodium carbonate or hydroxide present in the boiler water carried over is not measured as it is removed in the sampling device.

The method is based on *complete* removal of the cations such as ammonia, sodium, potassium. There is good reason to believe that such complete removal is not obtainable. It is well known that a single step acid regenerated cation exchange unit removes only a percentage of the influent cations. Tests have shown that for influent sodium concentrations of approximately 0.01 ppm little or no exchange results. Since hydrogen ion contributes a large share of the specific conductance measured after such an exchange unit, only partial exchange of sodium for hydrogen causes a relatively large error in the conductance measurement.

An excellent comparison of the ion exchange degassing method and the sodium tracer method is available in the results of a large number of tests run on steam samples from several different points in the steam system of a new large high pressure central station unit. This particular steam generator was operated during the tests without the feed of ammonia or any ammonia producing substance. The makeup water was prepared from high quality condensate from a low pressure turbine condenser. The condensate was passed through a mixed bed ion exchange unit. The ammonia and CO_2 in the steam was less than 0.01 and 0.1 ppm by the methods of test employed. The only chemicals added to the boilers were sodium hydroxide and phosphoric acid.

Continuous flow samples were passed through an acid regenerated cation exchange bed and the conductivity measured before and after the exchanger. Samples were collected at hourly intervals during the test program for sodium measurements.

These results are shown in Fig. 5 where specific conductance is plotted versus the sodium concentration. It is to be noted that both the specific conductance before and after the exchanger shows an apparently linear relationship with sodium concentration at sodium concentrations above 0.10 ppm and 0.05 ppm respectively but that below these values the specific conductance departs from this linear relationship. At low sodium concentrations the specific conductance values do not reflect accurately the sodium concentration and hence become a poor measure of carryover.

It is obvious from Fig. 5 and Fig. 3 that the cation exchanger is a considerable improvement over past mechanical sample degassing system. Even though the relationship between specific conductance and Na concentration is non-linear at sodium concentrations below 0.05 ppm, the technique would be extremely useful if it

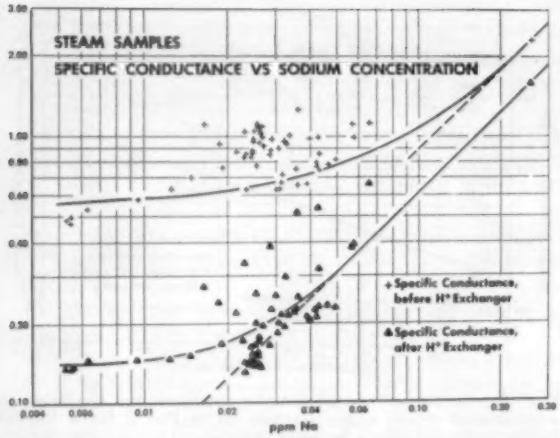

STEAM SAMPLES
SPECIFIC CONDUCTANCE VS SODIUM CONCENTRATION
+ Specific Conductance, before H⁺ Exchanger
▲ Specific Conductance, after H⁺ Exchanger
ppm Na

Fig. 5—Further comparison of available carryover testing methods is shown in curves for the ion exchange degassing method for specific conductance reading against the sodium tracer technique

were not for the fact that it is apparently only at Na concentration less than 0.010 ppm that there is assurance of freedom from soluble deposits in turbines. From the limited amount of data available it appears that sodium concentrations of (1) 0.000–0.010 ppm will not cause soluble deposits; (2) 0.010–0.030 ppm may; and (3) 0.030 ppm and up will likely cause soluble deposits. These values are at best only uncertainly resolved by specific conductance techniques.

Determining Accuracy of Tests

It is only fair that one should ask at this point whether the dispersion of the data evidenced by Fig. 5 could not just as well be attributed to errors in the sodium measurements whether by contamination, instrumental, or other. The same data plotted as sodium versus specific conductance might well be argued from this different viewpoint.

The test, however, of the sensitivity, reliability and general usefulness of a procedure is how well the results obtained with it check known and well established relationships. A good test therefore of these several procedures is the one based on the fact that for a given boiler under constant conditions of operation including pressure, load, and water level, the amount of dissolved solids in the steam is proportional to the dissolved solids in the boiler water.

Such a test was made using both measurements of sodium concentration and specific conductance, the latter after an acid regenerated cation exchanger. The results of this test are shown in Fig. 6 where the sodium concentration and the specific conductance (H^+) are plotted versus boiler water conductivity for three different sampling points.

The saturated steam samples in Fig. 6 were collected using a perforated sampling tube installed in the superheater inlet header. It is quite apparent from the graph that the sodium concentration of the saturated steam is proportional to the boiler water conductivity; it is equally apparent that the specific conductance results are not. Since the conditions of the test dictate that the amount of sodium in the steam must be proportional to the sodium in the boiler water, the results obtained by conductivity do not fit the conditions.

The superheater outlet samples in Fig. 6 were not collected using an approved sampling nozzle; they were collected from a connection on the end of the superheater outlet header. These samples were collected at the same time as the saturated steam samples. The usefulness of the sodium method is here well demonstrated. It is to be noted that the sodium concentration of the superheater outlet remains at a constant 0.026 ppm even though the saturated steam entering the superheater decreased uniformly from 0.049 ppm to 0.005 ppm. This means that the sample obtained contains only that sodium that is truly soluble in the sample at the 1100 F superheater outlet temperature. During the time that the sodium concentration entering the superheater was greater than the amount soluble in the steam at outlet temperature conditions a portion of the excess sodium deposited in the superheater. During the time that the sodium concentration in the inlet was less than the saturation amount salt deposits in the superheater dissolved in the steam and raised the concentration to saturation amount. Presumably such resolution would continue until all such deposits were gone.

It was stated above that only a portion of the amount of sodium salts above saturation deposited in the superheater. It appears that the insoluble portion that does not deposit remains entrained as a dust or as microscopic molten salt droplets. Sampling from the end of the header acted to separate this dust from the sample and left only that matter in true solution.

Confirmation of this separation is found in the samples obtained from the turbine condenser. It is to be noted that the sodium concentration of the condensate decreased as the saturated steam sodium concentration decreased until the point at which saturated and superheated outlet sodium concentrations were approximately equal. After this the turbine condenser sodium concentration remained constant at 0.021 ppm or 0.005 ppm less than the superheater outlet sample. A tentative estimate of the amount deposited in the superheater in this instance is 20–30 per cent of the amount entering in excess of saturation.

Since the sodium concentration found in the superheater outlet samples appears to be the saturation amount for 1100 F temperature, it is likely that the con-

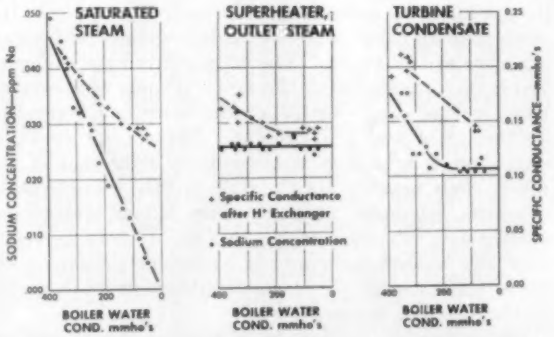


Fig. 6—Three different sampling points on a boiler held to constant operating conditions produced the above comparison curves for specific conductance measurements as against sodium determination

centration would be dependent on the temperature among other conditions. A study of the temperature records during the test in question showed that when the temperature of the superheater outlet decreased from 1100 F to 1025 F the sodium concentration of the superheater outlet samples decreased from 0.026 ppm to 0.018 ppm. While the range of temperature is too small to determine whether the relationship may be expressed as $\log C = (A/T) + B$ (where C = Na concentration and T = absolute temperature, degrees R), it is very interesting to note the magnitude of the temperature effect and to note that decreasing temperature decreases the solubility of the sodium salts involved.

It seems reasonable to say that the relationship of dissolved matter in the saturated steam, in the superheater outlet, and in the turbine condensate as shown by the sodium measurements could not have been determined by specific conductance with either mechanical or ion exchange degassification.

Conclusions

The use of the sodium tracer method to determine carryover, and to furnish information to aid in the solution of steam purity problems is greatly dependent on sampling techniques. The data presented show that it is possible to avoid contamination by intelligent care in sampling and further that the sensitivity and reliability of the instrumental part of the method is such as to point to errors in sampling and thus allow their correction. The sodium tracer method is at least ten to twenty times as sensitive as the best specific conductance methods and has the distinct advantage of being an analysis for a specific substance rather than a measurement of a property that is a complex result of many substances.

It now seems possible to collect information of sufficient accuracy and reliability to measure the rate of deposition of sodium salts in a superheater or a turbine under any set of operating conditions.

DISCUSSION

E. E. Coulter, Babcock & Wilcox Co., in discussing Mr. Rice's paper, picked up the fact that the addition of a filter for the secondary air supply greatly relaxed the requirements for atmosphere purity near the photometer and makes it appear that a photometer device can be devised for boiler room service. With such a device, Mr. Coulter exclaimed, it may some day be possible to collect data on the proportions of the various salts in the boiler water as against operating pressures and steam temperatures. With data such as this limits of allowable carryover can be realistic.

H. Lewis Kahler, W. H. & L. D. Betz, made specific references to various elements of Mr. Rice's paper in his comments. For example the author, Mr. Kahler, felt, should explain more clearly his way of applying the sodium technique in developing the data for Figs. 1 and 2. Similarly the feeling was expressed that Mr. Rice should give the sodium content in his distilled water, and also what type containers and measuring instruments he used for standard sodium solutions. Further that in Figs. 3 and 5 Mr. Rice concludes that condensed steam containing sodium of 0.0 to 0.01 ppm will not cause soluble deposits; 0.01 to 0.03 might cause deposition; 0.03 and up likely will cause soluble deposits. These, Mr. Kahler comments, should be backed up with supporting data.

In the way of adding background to his comments Mr. Kahler cited the work of **P. B. Place** in his 1954 papers on "Steam Purity Determination" wherein Mr. Place expressed the conviction that solids of saturated steam should be proportional to boiler water solids. This has been borne out in at least one case known by Mr. Kahler.

H. A. Grabowski, Combustion Engineering, Inc., mentioned his belief that Mr. Rice's work was timely and important. It has raised in Mr. Grabowski's mind a number of points which would profit from discussion: (1) the relationship of the accuracy of measurement of the impurity to the accuracy of the sampling, (2) the establishment of limits of permissible carryover to prevent soluble type turbine blade deposits, (3) the solubility data of sodium in high temperature and pressure steam.

Mr. Grabowski then expanded his points by specific references to the Rice paper. These references included the correlation of test results where sampling and analysis steps may not have received equal degrees of critical appraisal and attention, the assignment of a solubility value of 0.026 ppm to sodium salts at 1100 F, a value held to be well below equilibrium solubility studies of sodium salts in contact with superheated steam at high temperatures, and lastly the suggestion by Mr. Rice that the boiler should contain less than 0.01 ppm of sodium to prevent the formation of soluble type deposits on turbine blades.

In summation Mr. Grabowski urged the extension of such work as described by Mr. Rice to establish necessary parameters to control steam purity and prevent turbine blade deposits.

A. D. Herbert, Beckman Instruments, Inc., mentioned his primary interest was in the instrumentation problems referred to in Mr. Rice's paper. The costs, obviously, had to be balanced for fully automatic service as compared to occasional sampling against the protection this information gave. Next, Mr. Herbert sought some comment from the author on the type of filter employed and the manner in which it was set up in the laboratory and also what type sample containers were employed.

L. A. Winkelman, Public Service Electric and Gas Co., sketched briefly the position of the boiler operators now running units at pressures up to 2350 psi, knowing that deposits do form in turbines, and not having too much satisfactory information available from the conductivity method of appraising steam contamination. Mr. Winkelman's company decided the best way out was to eliminate in the treatment of waters with the boiler cycle any chemicals that would produce a soluble material. In addition Mr. Winkelman showed a plot of various samples from a number of boilers which caused Mr. Winkelman to cast some doubt on Mr. Rice's remark that sodium in carryover was proportional to sodium in the boiler water.

Which packing
for longer life in reciprocating service?

To 500F it's J-M Interlocked

because it cannot ravel or come apart

Made by an exclusive J-M process, Interlocked packing is braided from tough long-fibre asbestos yarns strongly interlocked in a solid integral structure. There are no jackets to wear through . . . no plaits to loosen. That's why it retains its strength and efficiency far longer than other types.

Interlocked also seals better. It is flexible and resilient, braided square for better contact and requires less gland pressure. Style 255 is effective against steam, hot or cold water, oil, weak acids and caustics. Furnished lubricated and graphited in ring and coil forms in sizes from ¼" and up.

To 750F it's J-M Superheat

because it does not harden under high heat

Designed specifically for superheated steam between 500F and 750F, Johns-Manville's Superheat packing is made of highest quality pure asbestos cloth which retains its resiliency even after long exposure to high temperatures. Woven tight, spiral wrapped and then pressed square, this cloth forms a firm resilient structure of superior strength and wearability.

Style 167 Superheat is bonded with a special heat resistant compound. No excess is present to carbonize in use. Density is carefully controlled for minimum gland pressure. Furnished graphited in ring and coil forms in sizes from ¼" and up.

Your local J-M distributor carries full stocks of Interlocked and Superheat and other packings. Call him today or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Johns-Manville PACKINGS, GASKETS and TEXTILES

Seventeenth Annual Water Conference

MORE than 560 engineers registering from all 48 of the States and four foreign countries (England, Italy, Mexico and Canada) attended the Seventeenth Annual Water Conference sponsored by the Engineers' Society of Western Pennsylvania at the Penn Sheraton Hotel, Pittsburgh, October 22–24, 1956. As usual, this meeting represented the major national conclave on the problems of water and water conditioning held this year. The Eighteenth Water Conference dates were announced as October 21–23, inclusive, in 1957, also for the Penn Sheraton. Those papers believed to be of principal interest to the readers of COMBUSTION are reported below.

Automation

"Automation of Water Treating Equipment" by **Paul H. Coleman,** Bechtel Corp., reviewed the changes in instrumentation and the progress of automation as they affect the precipitation process and the ion-exchange process. In the case of the precipitation process Mr. Coleman began with the cold, lime-soda softeners when they were handled as a batch-type operation. Instrumentation, he felt, started to develop when this batch operation was converted to continuous since the conversion required some method of relating rate of addition of treating chemicals to raw water rate of flow. The author then discussed a number of devices developed over the years to achieve this goal. It was inevitable that the transfer of intelligence from the motion of these mechanisms would lead to proportioning. As the flow meter developed it assumed control of proportional feed of treating chemicals as well as proportional de-sludging. Similarly the author checked back on the progress of the hot process softeners. The availability of reliable photoelectric, conductivity and pH apparatus are further steps toward automation and the liberation of the operating man with his sample container and burette. Yet the need exists for positive monitoring equipment for the precipitation process.

The ion-exchange process, however, seems to have the edge over the precipitation process, in the author's opinion, as regards automation. The reasons he gives are many, for example, the multiple unit nature of the ion exchange process abetted the concept of central control; first costs, which in general included more instrumentation for the process, helped some; the availability of reliable instrumentation of minimum complexity advanced automation and lastly operating costs as well as inspection and testing time greatly enhanced the adoption of automation for the ion exchange process.

Discussion

R. C. Alexander, City of Los Angeles, Dept. of Water and Power, remarked that his experience indicated the conductivity and pH apparatus were sufficiently reliable to warrant their use as a control component and not merely for alarm in future ion exchange units. Automatic analysis of low silica concentrations appears to Mr. Alexander to be the most needed development at the moment so that full utilization could be made of ion exchange capabilities.

As far as all forms of water treatment go Mr. Alexander believed dependable automatic equipment is needed to provide effective filtration. But there is room for advance in many areas. If the proper equipment were available, Mr. Alexander holds, predetermined polyphosphate concentrations for corrosion prevention could be maintained. Moreover automation could be extended to include automatic sampling and analyzing of boiler feedwaters and blowdown so that information could be fed automatically to equipment that would take appropriate action for conditions.

Charles H. Guldner, Permutit Co., felt that the development of the new ion exchange processes with their long and complex regenerating cycles made automatic operation advantageous. Equipment for the precipitation processes, on the other hand, are presently beyond the limits of practicability.

H. E. Bacon, Sheppard T. Powell Organization, advanced the thought that automation of water treating equipment is balanced against cost of operators at anywhere from $18,000 to $25,000 per year for round the clock coverage. But management, Mr. Bacon claimed, should not expect fully automatic operation without personnel to patrol the area on schedule and respond to alarm systems by prompt corrective measures. Equipment manufacturers, especially central control panel people, should avoid stressing an attractive panel that involves such a maze of wires and tubing that instrument specialists have to do the trouble-shooting. Rather, says Mr. Bacon, make the units rugged and simple.

V. J. Calise, Graver Water Conditioning Co., commended Mr. Coleman for listing the various areas of design requiring additional work and development for automation and pointed out that the characteristics of the changes in the composition of the available raw water supply and the degree of quality needed for the effluent would determine largely the type, degree and design of automation and control for any given plant.

Coagulants and Coagulation

R. W. Kirkconnell, National Aluminate Corp., in his paper, "Polymeric Coagulants for Clarification of Turbid Waters" opened with the statement that by 1975 the U. S. water needs will go from the present 262 billion gallons per day to 453 billion gallons per day. This increase in volume can only be at the cost of a decrease in quality so that more and better clarification will be needed for both effluent and influent waters. The average industrial water user will require in 19 years about 73 per cent more throughput capacity than he now has. Fortunately, as Mr. Rice pointed out in his ESWP paper[1]

---

[1] "Uses of Coagulant Aids," J. K. Rice, Sixteenth Annual Water Conference, 1955, COMBUSTION, November 1955.

of a year ago there have been some chemical improvements in the field of organic coagulant aids. Some are non-ionic; some, anionic and now a cationic polyelectrolyte has been developed which is said to be both a coagulant and a coagulant aid. This new development is discussed in Mr. Kirkconnell's paper.

One of the first papers devoted exclusively to the uses and properties of cationic coagulant aids was given at the Minneapolis ACS Meeting in September, 1955, according to the author. From this paper certain statistics were provided. For example laboratory tests have revealed that filtering a water clarified with alum plus a cationic polyelectrolyte through 8-40 Anthrafilt, compared to a water clarified with alum only resulted in an increase in filter runs of 50 per cent. These results have been verified in the field, with reports ranging from 0 per cent to 100 per cent. Quantitative tests showed that no amount of polymer gets through a filter bed and further passing a cationic polymer through an anion exchanger in any quantity produced no effect upon the capacity of the beds. Passing 10 ppm through a cation exchanger had no effect either upon the bed. By charging a 600 psi boiler with 50 ppm of polyelectrolyte no effect was noted upon deposits other than they were laid down more uniformly.

Discussion

W. D. Fair, Gulf Oil Corp., recounted certain experiences with a synthetic organic non-ionic polyelectrolyte as a background for questions that existed in his mind. The purpose for Mr. Fair's venture into the use of these chemical coagulant aids was to determine if the flow rate into a 4500 gpm horizontal flow coagulator could be improved by chemical means only and if the quality improved could the flow rate through the filters be increased. Briefly this is the gist of Mr. Fair's experience.

A high filter head loss developed and backwash water losses were accordingly increased because the polyelectrolyte created a tough, dense, almost sticky floc. This floc carryover failed to penetrate a following gravity flow filter bed to any depth but rather formed a mat over the filter media. This floc tended to cling to filter flumes and walls.

Mr. Fair recognized that his polyelectrolyte was non-ionic and hence he wished to know the effect of a cationic polyelectrolyte on nature of floc carryover, the criticality of point of addition to the system and the cost of the polymer as against activated silica.

T. E. Larson, Illinois State Water Survey, commented that jar tests, although reasonable in the laboratory, were not always in the best repute. Lack of correlation with plant experience is probably due to excessive short-circuiting and dead corners inherent in the plant design. Also excessive turbulence destroys a weak floc. In other instances, conducting such tests at room temperature may produce results not in accord with plant operations at near freezing temperatures.

M. E. Gilwood, Permutit Co., stated that tests at his organization indicate that polymeric aids are helpful mainly on waters of low to moderate turbidity. Standard coagulants work well on high turbidity waters. Further the polymeric chemicals have not proved to be of much assistance in improving color removal by the standard coagulants.

As the result of the above tests and certain field experiments Mr. Gilwood advanced a number of precautions to keep in mind. These precautions covered (1) toxicity, (2) effect on ion-exchange units which seems to be adverse with cationic polymerics but not so with the non-ionic, (3) effect on process use of the treated water which, he felt, should indicate caution in the use of the polymeric coagulant aids at least until experience is much richer than at present.

Joint Research Committee

P. B. Place, Combustion Engineering, chairman, Joint Research Committee on Boiler Feedwater Studies, reported that his committee has been under reorganization for the better part of a year. That reorganization was slated to affiliate the Committee with the American Society of Mechanical Engineers and divorce it from the remaining five supporters. This reorganization has been somewhat drawn out in its realization but Mr. Place felt that it would soon be completed and the Committee could begin in earnest to carry out its function, namely, the encouragement of research activities. In concluding, Mr. Place mentioned the names of the Committee's major personnel as well as the chairman of several subcommittees.

Nuclear Water Technology

Paul Cohen, Atomic Power Division, Westinghouse Electric Corp., originally slated to present a paper on "Chemistry of Pressurized Water Nuclear Power Plants" had this material rejected from a clearance standpoint. In its stead, as S. F. Whirl, chairman of the session, expressed, Mr. Cohen served up a "hash" compounded of previous material released on the subject of the pressurized water reactor now building for the Shippingport project of Duquesne Light Co.

Mr. Cohen launched his talk with a schematic diagram of the Shippingport nuclear and steam cycles. He explained the thought behind pressurizing and the means employed to effect this pressurizing. Next, he showed a photo of typical fuel elements and briefly described their makeup. From this point Mr. Cohen moved over to a discussion of design considerations applied to the Shippingport Station and certain of the philosophy behind these considerations.

Mr. Cohen spent some little time on the existence of dissolved oxygen and other gases within the pressurized water acting as moderator and cooler. The radiation effect enhances the likelihood of dissociation and formation of water, as well as the formation of ammonia and nitric acid. The rates of formation for these various undesirables vary, however, but need to be understood and corrected.

Similarly, Mr. Cohen brought up other points of consideration such as the problems of deposits within the system, the limits of accessibility for different parts of the system, the life of fuel elements, and the difficulties of waste disposal.

A. C. Stanojev, Duquesne Light Co., followed Mr. Cohen with a paper on "The Mechanical Features of the Shippingport Station." This particular paper had been presented earlier to the Pennsylvania Electric Associa-

tion, but proved highly interesting. Mr. Stanojev discoursed on the physical arrangement of the station and then gave specific data on the overall size and dimensions of the major components in the nuclear cycle. He also covered certain of the problems that shielding and safety considerations had imposed upon the installation.

Demineralization

Gordon W. Brush, Catalytic Construction Co., **S. B. Applebaum,** Cochrane Corp., and **Gustave J. Angele,** Union Carbide Nuclear Co. presented the "Mixed Bed Demineralizer Operations at AEC Facilities, Oak Ridge, Tenn." This paper described the decision to install a water treating system of 800 gpm capacity involving first activated carbon purification (to absorb as much organic material as possible to protect anion resin from rapid fouling), secondly, an automatic large high pressure mixed bed demineralizer plant (to reduce dissolved solids to below 1.0 ppm), thirdly, a vacuum deaerator (to remove dissolved gases).

Mr. Brush described the problem to be solved and the considerations that determined the specifications he wrote. Mr. Applebaum, then, discussed the equipment and its design features. Mr. Angele compared operating experiences with the new plant as against the previous demineralizer installations.

The specifications were drawn up to restrict the bidders in the following items: type of resin, quantity of resin, (exchange capacity rating) size of vessel, auxiliary equipment required, detailed design of internals, detailed requirements for controls, instrumentation and graphic panel. The selection of the type anion resin proved the most controversial of these items with manufacturers offering a variety of choices.

As a result a porous anion resin, Type I, was specified as well as an effort to eliminate any possible contamination from pickup of undesirable elements from supporting beds. A continuous pretreatment using activated carbon filters regenerated by steam was sought.

Discussion

J. S. Grant, Toledo Edison Co., described in the way of comment his company's experience with two demineralizers employed for cleanup of condensate at their Acme Station. There a project had been initiated to bleed excess steam from the output of two 900 psi boilers through a reducing station into the 235 psi header to supply low pressure headers. The problem was the effect of returning this bleed steam (roughly 100,000 lb per hr) to the 900 psi units. Usual makeup was the effluent from the two bed demineralizer.

At the Acme Station the condensate from the low pressure turbine hot well passes through a horizontal plate, diatomaceous earth filter for oil removal and then through a two bed demineralizer to the 900 psi boiler makeup system.

Richard Herrington of Rohm and Haas Co. expressed the feeling that the source of the difficulty of the previous demineralizers at Oak Ridge was trace quantities of weak organic acids in the water supply. The solution could come from removal or reduction of these trace organics from the water supply or development of non-fouling resins or devising techniques to clean exchangers.

The answer to the first approach was more effective pretreatment and the Union Carbide Nuclear Co. did this by chlorination, coagulation and then filtration. In some cases they employ activated carbon filters.

The resin manufacturers tackled the other alternatives. They have developed resins which are superior to the older ones in their resistance to fouling. Similarly the manufacturers have advanced techniques to where the clean up of fouled exchangers has proved quite satisfactory in some instances to where a satisfactory, economic life for the resins are obtained.

Steam Purity Determinations

"Instrumentation for the Determination of Steam Purity" by **E. A. Pirsch** and **F G. Raynor,** Babcock & Wilcox Co. delved into the difficult problem that the influence of boiler water concentration on steam purity had never been conclusively demonstrated and hence the attempt to settle on an allowable total dissolved solids to produce an ideal steam proved most trying. As a result, an individual limit had been set on the specific contaminant, silica. Yet records of turbines supplied with steam of apparent equal purity have had completely different histories of soluble salts deposition. Such discrepancies have pointed to the conclusion that the electrical conductivity measurement method may not be reliable for determining low value steam contamination.

As a result the above conclusion plus the shortcomings of the available measurement techniques led the authors to search for a more adequate means for determination. This search produced the system of tracer techniques employing radioactive material and natural sodium in the boiler water. In this technique radioactive phosphorus (P^{32}) was employed and allowed detection of tracer concentrations as low as one part in ten trillion. The chief advantages are high sensitivity, freedom from contamination and elimination of the effects of dissolved gases. Yet the cost and precautions to safeguard personnel ruled this technique out. However the authors feel this method would be excellent for a nuclear reactor of the boiling water type.

The final tracer material the authors hit upon was sodium. Its sensitivity is nearly as great, and the effect of dissolved gases are also eliminated. The one drawback is a lack of freedom from contamination. The authors believed, however, proper sampling and analysis will get around this difficulty. The paper then provided comparison of results of carryover tests by various measurement methods.

Discussion

E. B. Morris, American Gas and Electric Service Corp., agreed with Pirsch and Raynor in that the measurement of steam purity with respect not only to boiler guaranty but to everyday performance was of vital concern to the operator and felt it perplexing that the turbine itself should serve as a far more sensitive instrument than any conductivity meter in evaluating degree of carryover. Silica, he maintained, is not the only offender with boiler water salts frequently dominating in cases of mild fouling. He cited recent experiences with the AGE system wherein as much boiler water

salts were removed as silica in washing down a 215 mw turbine operating at 2000 psi, 1015 F. Turbine capability improved 3 per cent in the process.

The authors' paper, Mr. Morris pointed out, failed to mention errors due to polarization and adsorption in employing the conductivity method such as Powell described in 1937 and Kaufman in 1941. Further the problem of obtaining a truly representative sample remains to be solved so that measurement for absolute values of carryover by any method is questionable. As for the sodium tracer technique with flame photometry it permits adapting presently available components with only minor modifications to give a continuous recording instrument but it must be geared to economic considerations. At current list prices for standard cylinders the annual cost of gas for the present design of hydrogen burner approximates $14,000.

E. F. Lynch, Gulf Oil Corp., remarked that the sodium tracer technique now gives us an excellent tool to help in understanding the mechanism of steam carryover and should assist in determining the tolerable limits of steam contamination for optimum operation of steam consuming apparatus. For the moment Mr. Lynch expressed the feeling that it would be of interest for the authors to comment on the relationship they found between steam purity and boiler water solids and whether these relationships or proportionalities held alike for several boilers and boiler waters reported as tested.

R. A. Lorenzini, Foster Wheeler Corp., represented by a **Mr. Gulbronson,** raised the question as to just how Mr. Pirsch and Mr. Raynor had effected the splitting of the steam sample. If the sample had not been split properly so that equal samples were going to the Hagan degasser for the conductivity checks and a similar sample was directed for the sodium tracer checks the comparisons between the tracer technique as against conductivity became of less value. Further, unless the sampling takeoffs were isokinetic with respect to the main steam line flow the sample could be questioned as to its representativeness.

C. E. Kaufman, Hall Laboratories, represented by **Leonard Hiley,** discussed many of the specific figures and raised the points that occurred to him. For example with one illustration, Fig. 1 of the authors' paper, Mr. Kaufman felt that steam samples taken ahead of the degasser would have their measurement values affected by the presence of moisture. Similarly unless special precautions were taken in splitting the sample errors could appear in the final measurement values especially when used for comparison purposes.

J. F. Wilkes, Dearborn Chemical Co., expressed the fear that a loss of perspective could be developing and that the conductivity method of measuring contamination was not exhausted in its possibilities. There has been a steady improvement in the preparation of samples for conductivity checks such as the degasser, then the hydrogen cation exchanger. Further this method is the best for the typical industrial boiler range and hence its advance should not be overlooked since it represented a valuable tool.

Mr. Ross, Central Electricity Authority, advanced the thought that the conductivity technique could be increased in sensitivity by a factor of one thousand. The technique for such improvement he held to be relatively simple and referred the audience to the treatment suggested by Professor Gurney at the June meeting of the American Society for Testing Materials.

Quality Measurements

The paper, "Quality Measurements by Flame Photometer" by **J. K. Rice,** Cyrus Wm. Rice Co. has been printed in its entirety in this issue and appears on pp. 57-61. Mr. Rice has accepted the premise advanced by Messrs. Pirsch and Raynor in their paper above and has looked into the possibilities of adapting the sodium tracer technique to the power plant. His particular presentation went into a discussion and development of a technique that bids fair to remove flame photometry from definite limitations as a lab instrument.

Non-Destructive Testing

"Inspection of Non Magnetic Tubing in Corrosive Service by the Probolog Method" was presented by **Frank U. Neat,** Baltimore Gas and Electric Co. The Probolog, as Mr. Neat pointed out, is a non-destructive test instrument that can be used to detect wastage of a corrosion type and thereby permit an estimate to be made of the remaining life of the tubes by duplicate Probolog surveys at stated periods in a heat exchanger or condenser with a power plant. In addition this device can determine the site of localized wastage, cracking, pitting and the like. There are cases where the micrometer shows no wastage where the Probolog indicates as much as 30 per cent. The discrepancy, Mr. Neat commented, was due to intercrystalline action to which the micrometer was insensitive.

The great difficulty to the widespread adoption of this device developed by the petroleum industry is the time required to understand its workings and the fact that the unit has not been standardized in manufacture so as to permit comparisons between results from one Probolog as against another.

Discussion

J. M. Decker, the Detroit Edison Co., mentioned that his concern purchased a Probolog in September 1950 and have employed it in inspecting tubes in feedwater heaters and condensers. As a result his Company has learned they can paint the ends of tubes grown thin at just these points and gain extra service. Similarly they know that tubes that have thinned out along their length are beyond such remedies. Detroit's experience supports Mr. Neat's in the need for considerable knowledge and experience with the Probolog before it can be made the valued tube it is now considered.

M. V. Long, the Shell Development Co., agreed that satisfactory results are obtained with (1) a very careful scrutiny of the chart records and a correlation of these test results with visual inspection of samples, (2) attention to calibration of the instrument, particularly when more than one Probolog is used at the same or different

times to obtain results that can be quantitatively compared. However different Probologs can be made substantially identical by appropriate servicing and adjustment of the electronic and the electromechanical sections.

Mr. Long reported that contrary to the authors understanding a Probolog type equipment is being developed to operate at speeds up to 100 ft per min and to actuate a sorting mechanism depending upon the information from the Probolog so that full tests can be made on all the tubes comprising a piece of equipment early in its life.

E. W. Dreyman, Kirkaldy Corp., followed Mr. Long's report with the statement that his organization has inspected condenser tubing with driving rolls to move the tubing at speeds up to 200 ft per min. Further that the sensing head has been improved to use complete 360 degree phasing as compared to only four fixed phase angles provided in earlier models. Finned tubes can be inspected by this means but the frequency of the voltages in the sensing head have to be altered to dampen out the O.D. variations and permits I.D. defects to register.

R. G. Kern, Union Electric Co. of Missouri, collaborated with **A. O. Blattner** of the same firm on comments which Mr. Kern presented. These comments included a recitation of some direct experiences that Union Electric had had with the equipment and the observation that the Probolog becomes a more valuable tool with use.

F. N. Alquist, Dow Chemical Co., and **A. M. Guy,** Southern Indiana Gas and Electric Co., presented a paper on "Non-Destructive Thickness Measurements of Boiler Deposits" and confined their remarks to the Turner scale-thickness indicator as developed by Howard L. Turner of Jackson, Michigan. This paper grew out of the answers to a questionnaire originally sent to all members of the Boiler Feedwater Committee and a partial list of users of the Turner indicator. The ASTM had published in 1954 a tentative method for determining the thickness of tubular deposits based on the Turner instrument.

The questionnaire answers were broken down by the authors in the broad categories of significant statements, advantages, disadvantages, accuracy of the instrument and use of data. After a brief description of the instrument's workings, certain samples of each of the above categories were given. In general the indicator proved satisfactory to those who had bought it and gave immediate information of scale condition with good results for very hard scales. The most frequently mentioned disadvantage was the difficulty of tube bends giving everything from erratic readings to physical impossibility to move the device beyond a third bend.

L. B. Losee, E. I. du Pont de Nemours & Co., followed with his paper "Experiences With the Turner Scale Thickness Indicator."

In 1950 the author purchased a Turner indicator. Mr. Losee then described this instrument and by slides showed certain of the results and the interpretations put upon these results. This older model suffered when it was asked to measure deposit build-up around tube bends. The new model probe head is held to be quite superior.

Discussion

T. H. Haskins of the Haskins-Turner Co., with acknowledgment to Howard L. Turner of Consumers Power Co., commented that the results reported by Alquist and Guy were based on the earlier Turner model and that the experience of Mr. Losee was more up to date.

Further improvements are in process. For example, a 24-volt indicator is now available and the original bright tempered spring steel tape with its affinity for rust and corrosion has been replaced with a full, hard, stainless steel one of about the same cross-sectional dimensions. The effect of magnetic iron oxide deposits on the indicator readings have been under investigation. Where these deposits run to 70 to 75 per cent of the tube scale, the indicator reads about 8 to 10 per cent low. Where supply voltage fluctuates, a small voltage regulating transformer is to be used with the indicator.

Electric Membrane

"The Present Status of Electric Membrane Demineralization" as presented by **William Katz,** Ionics, Inc., opened with a treatment of the previous methods of distillation of a saline water to obtain fresh water, and the costs involved, something around $1.60 to $3.00 per thousand gallons for the two most modern large water distillation plants. Investment costs for these same plants run similarly high—$2.00 to $3.70 per daily gallon of capacity. The American Water Works Association found in 1950 the mean price paid for delivered municipal water was $0.20 per thousand gallons and required an investment of about $0.50 per daily gallon of capacity. The electric membrane process costs about 0.31 per M gallons up to 5000 ppm solids.

Harry Blackwell, Texas Electric Service Co., stated that the figures as advanced by Mr. Katz agreed with experimental data put together by his own concern for the operation of membrane stacks. But much work needs to be done on the stack construction and the size of the individual components before this process is attractive for very large quantities of water.

Texas Electric Service Co., located in a light rainfall area where waters run high in sulfates and chlorides, saw the membrane process as a two-fold advantage to them. If it could make the water fit to use at reasonable prices, the area would be attractive for an industry build-up. Further, the fact that the process used electricity made it a possible load builder. As a result the Company leased a four-stack membrane from Ionics, Inc., to expedite the development of the process. After 4364 hours of operation they found this:

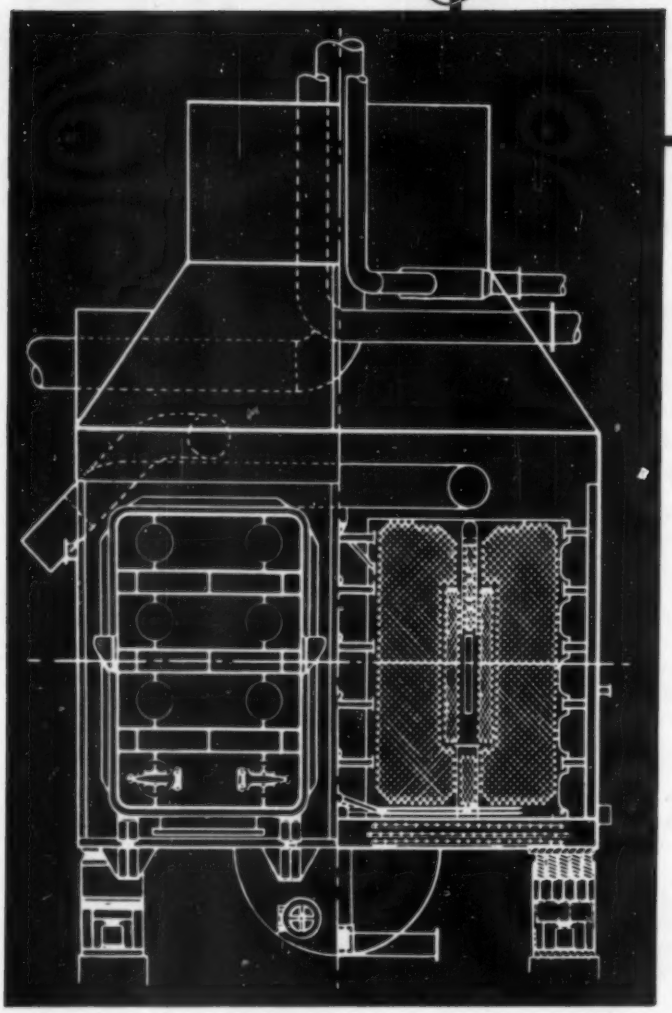
1. Electrical energy requirements were reasonable and within the figures anticipated by Ionics.
2. The membrane type employed had a two to three year life and the anodes used had a relatively short life.
3. The membranes scaled up badly unless extensive pretreatment was made to give the water a negative scaling index.

As a result of these tests, Ionics have improved their membranes and with new units under test much better results are forthcoming. The anodes are giving good service, the scaling problem is much improved, demineralization has been increased to 40 per cent per stack with about 55 per cent recovery of the initial feed.

DUAL BANK Condensers

by C. H. Wheeler

For Your Electric Generating Plants of Tomorrow



- Specifically designed for larger, more efficient electric generating stations.
- Adaptable to your station layout.
- Designed to minimize field erection problems.
- Additional steam lanes shorten path and resistance to steam travel.
- Lower pressure drop and higher vacuum.
- "Zero" condensate temperature depression.
- DEAERATION . . . 0.01 cc per liter is attainable.
- Purity of condensate.

At C. H. Wheeler the most modern engineering techniques are at your service. Let our engineers help you. Contact your local representative or

C. H. WHEELER MANUFACTURING CO., 19th & LEHIGH, PHILADELPHIA 32, PA.

Manufacturers also of Vacuum Equipment • Pumps for Circulating Water, Condensate, Water Supply and Drainage
Marine Auxiliary Machinery • Special Products for Atomic Service

WE 607

C.H. Wheeler OF PHILADELPHIA

Atomic Industrial Forum Conference of 1956

The theme "Management, Economics and Technology For the Atomic Industry" was chosen as the basis for the 1956 Conference of the Atomic Industrial Forum which met in Chicago, September 25–27. A concurrent Trade Fair was held at the Navy Pier, also in Chicago, from September 24–28. Attendance at the Forum was high with better than 1000 registrants including more than 100 from about 25 foreign countries.

The technical program was an extensive one. About 65 papers were presented in all. There were three luncheon speakers in addition to the one at the main banquet and an evening press round table on reactor safety. From the viewpoint of the power industry this Forum, following as closely as it did upon the heels of the Geneva Atomic Energy Conference of 1955, suffered some from a dearth of truly new information. There were several sessions, however, on the legal and insurance phases of atomic energy development which were of definite value to American management.

Economics of Reactor Systems

Dr. Chauncey Starr of North American Aviation, Inc. opened this session with a paper on the "Sodium-Graphite Reactor." Dr. Starr stated that the capital charges for construction in the U. S. of a 75,000-kw plant have been estimated to be approximately $165 per installed kilowatt of electrical capacity for the reactor portion; $55 per installed kilowatt for the sodium steam generator; and $120 per installed kilowatt for the electrical portion of the plant. These three items total $340 per installed kilowatt for this particular nuclear plant.

Using 15 per cent annual charges against the capital investment and assuming an 80 per cent load factor, the contribution of capital charges to the power costs is 7.3 mills per kilowatt-hour.

The total fuel costs for the 75,000-kilowatt plant have been estimated to be 2.2 mills per kilowatt-hour and the fixed operating and maintenance charges of the nuclear plant are assumed at 2.0 mills per kilowatt-hour. The total combined cost of power from this plant is estimated at 11.5 mills per kilowatt-hour. As a comparison, the average total cost for a similar size conventional hydrocarbon fired plant in the United States is 6 to 8 mills per kilowatt-hour.

The second speaker, **O. B. Falls, Jr.,** General Electric Co. maintained that present progress in atomic power plant development by private industry will make such plants economically competitive with conventional power plants in many of this nation's high power cost areas "well before" 1980. Improvements in constructing comparatively large (above 25,000 kw) plants and their fuel elements eventually would make atomic electric power cheaper and more abundant than today's conventionally produced power.

Capital costs of large atomic plants should be reduced by at least 25 per cent in the next ten years. By 1980, these costs should be down 35 per cent, or to 65 per cent of today's figures. This will result in first cost values well within the range of conventional plants. In addition present costs of nuclear fuels are expected to come down rapidly, far more rapidly than fossil fuel costs, but Mr. Falls does not believe they will reach the same level as conventional fuel within the next five years.

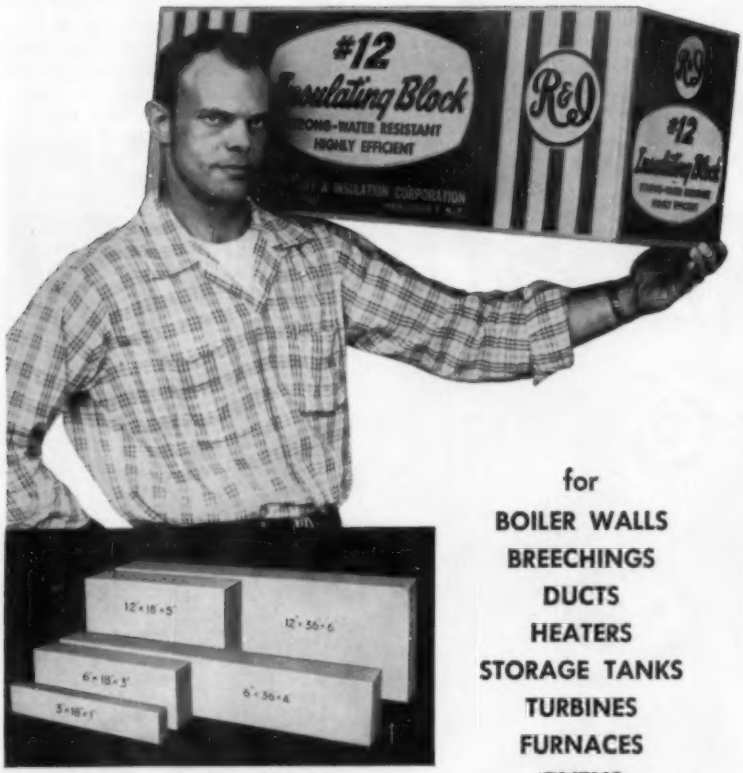
The importance of using properly deaerated water in modern industrial boilers is typified in this 120,000 lb/hr L*A Deaerator serving the new IBM Plant at Kingston, New York. Industry has long recognized that boiler feed water should be free of oxygen and other corrosive gases. Removal of these gases in the modern L*A Deaerator prevents costly corrosion and maintenance in boilers, boiler feed pumps and piping, steam lines, traps and condensate return piping, pumps and systems.

As pioneers in the field of water conditioning, L*A has helped industry solve these and similar problems, effectively and economically, through the development of fine equipment such as the Deaerator shown here. L*A Water Softener Company maintains complete engineering, fabrication and service facilities for all phases of water conditioning. All equipment and piping assemblies are made up in our shop to assure proper fitting . . . then delivered in a single shipment to make installation quick, easy, economical.

Send for FREE Bulletin 102

L ★ A WATER SOFTENER COMPANY
1007 Air Way Glendale 1, California

It's Lighter
It's Stronger



for
BOILER WALLS
BREECHINGS
DUCTS
HEATERS
STORAGE TANKS
TURBINES
FURNACES
OVENS

- *Lightweight* • *White*
- *Strong* • *Rigid*
- *Clean sharp edges*
- *Coated—little or no dust*
- *Unaffected by steam or water*
- *High insulating efficiency*

R & I #12 Block applied to refractory tile of boiler wall.

Available in thickness from ½" to 12" and sizes from 3" x 18" to 12" x 36". Prompt delivery.

REFRACTORY & INSULATION CORP.

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

124 WALL STREET • NEW YORK 5, N. Y.

W. T. Moore, Babcock & Wilcox Co., third speaker of the session, chose "Economics of Pressurized-Water Reactors Fueled with Uranium-235 and Thorium" for his paper. He opened his comments with the expressed belief that a self-sustaining nuclear fuel economy had two paths to follow. There is the path of the uranium 238-plutonium cycle, which he claimed culminates in a fast plutonium breeder reactor, and there is the path of the thorium-uranium 233 cycle, which many hope will culminate in a thermal thorium breeder reactor. The nuclear power business will be established on an enduring basis when either one of these two breeding cycles is realized on a basis which is financially competitive with conventional fuel cycles.

As a result of the successful performance of the Nautilus as well as its prototype at Arco, was held by the author to be generally conceded that the pressurized water reactor is the most advanced and best demonstrated power reactor type today. The combination of a pressurized water reactor and its largely-proved technology with the characteristics of the thorium-uranium 233 cycle is a combination which may lead perhaps within a few years to a self-sustaining fuel cycle in which no uranium 235 will be required after the initial charge. If such a cycle can be achieved there seems to be little question that a competitive financial situation will be reached in a number of countries outside the United States where conventional power costs are higher than they are here. More careful paring of costs will be required to achieve a competitive dollar economy in the United States.

There are, however, in a pressurized water reactor two complicating factors, (1) the cost of fabricating fuel elements, and (2) the cost of chemical reprocessing to recover the fissionable fuel remaining at the end of the operation, including that converted from fertile material in the operation of the reactor. These two items, with their many ramifications, represent the heart of the economic problem of all solid fuel reactors today, and the key to economic nuclear power lies in reducing the cost of fuel-element fabrication and chemical reprocessing, and perhaps even more importantly in the optimization of design to effect reductions in fuel element and reprocessing costs.

It seems possible, the author stated, eventually to design our way out of using solid fuel elements altogether, so that the pressurized water reactor becomes an aqueous homogeneous reactor with the fissionable fuel in solution in the water.

The last speaker, **U. M. Staebler,** chief, Civilian Power Reactors Branch, U. S. Atomic Energy Commission, made "A General Survey of Reactor Economics." Economic studies, he pointed out, have played and are continuing to play an important part in planning research and development. They have helped to select reactor systems which look especially promising on the basis of available technology and have served to identify the development problems which appear to be most important in reducing the cost of power from these systems. They have established sets of assumptions which, if realized, would result in nuclear power costs in a competitive range. Thus, they have established goals within the development program.

In order for the evaluation studies to be effective in guiding the research and development effort, there must be continuous exchange of information between groups responsible for these functions. One of the most difficult problems in using economic evaluation studies to guide the development program arises from the fact that different reactor concepts are at different stages of development. It is impossible to make truly comparable cost studies of projects in widely different stages of technical development. Yet, the initiation of an extensive development effort on a new concept must be justified on the basis that the concept offers certain advantages or economic promise in a specific size or for a specific application. Again, judgment and faith can easily become more important than fact or technology.

New Power Reactor Concepts

Milton C. Edlund, Babcock & Wilcox Co., led off a four-paper meeting on New Reactor Concepts. In his paper "Liquid Metal Fueled Reactor" the fuel is a solution of uranium in molten bismuth. Bismuth, as Mr. Edlund emphasized, is remarkable in that so many of its properties coincide with the reactor designer's specifications for an ideal fuel carrier. It not only has a low vapor pressure at temperatures in the range of 1200 F and a low neutron capture cross section, but is compatible with the cheapest high temperature moderator, graphite, and with inexpensive low chrome steels such as Croloy $2^1/_4$. The solubility of uranium in molten bismuth above 300 C is more than sufficient to establish a chain reaction in the various two region breeder reactor designs which have been proposed.

The low neutron absorption cross section of Bi, as well as its compatibility with graphite permit the possibil-

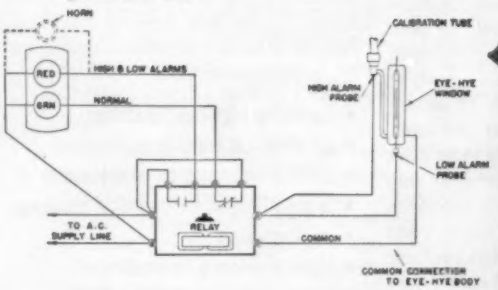
Why not *triple* your boiler water level safety!

Remote reading Reliance EYE-HYE gives you extra sound and sight alarms when you add the Levalarm

Improve the safety of water level supervision *even more* than EYE-HYE's recognized remote reading advantages; add *extra alarms* at small cost. Reliance electrode Levalarm EA9 augments the illuminated sharp-reading EYE-HYE with vibratory horns or signal lights, or both. They work instantly to alert operators when water levels reach danger points.

The boiler water itself calls the signals! Stainless steel electrodes with teflon insulation pick up a tiny current. Sensitive relays make or break independent circuits that operate the alarms. Levalarms work on low pressure or high.

Reliance Light Indicators, 2-light or 3-light, show green for normal water level — red for dangerous low or high condition. Horns are sturdy noise producers that demand action . . . Low alarm Levalarm can be installed on most EYE-HYEs in service. High alarm facility must be added at our factory. Send EYE-HYE serial number and ask for catalog section C6.



Wiring diagram for high and low alarm hook-up with 2-light indicator and/or horn.

Example of compact hook-up—EYE-HYE with horn and 2-light indicator. The extra signals can be placed any desired distance from the EYE-HYE.

Electrodes used in Levalarm EA9 withstand effects of high temperatures. Require no adjustment.

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio

200-2

"Good fences make good neighbors"

THERE'S TRUTH IN THAT OLD ADAGE— WHEN YOU'RE TALKING ABOUT A BOILER.

Steel and water, by the very nature of things, are hardly the best of neighbors. Just as water can never *improve* boiler metal, so likewise it never loses its capacity to impair. Merely to hold the line challenges today's metallurgical and chemical knowledge . . . even as industry moves swiftly on to atomic power reality and its newer problems.

That's why today — fifty years after the first Apexiorized boiler went into service — consulting-engineer specifiers, boiler-insurance recommenders, and operating-engineer purchasers continue to look to Apexior Number 1 — the simple, brushed-on barrier that keeps steel and water good — and safe — neighbors.

No matter how well a boiler is operating — or how perfectly it is maintained — whether it be a large central-station steam generator, a small heating unit, or anything in between—Apexior Number 1 can make that good boiler better . . . for only Apexior makes any and all of these contributions to steaming performance. . . .

- an end to high-heat oxidation
- no chemical bonding of deposits
- maintenance of high heat transfer
- a good barrier for chemical cleaning
- no carry-over
- high resistance to oxygen
- full resistance to boiler water chemicals
- corrosion immunity
- gun-barrel smoothness, for excellent wetability

Before you order a new boiler, or take an old one off the line — let us bring you up to date on Apexior.

MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS

ity of designing a high temperature Th breeder operating on fissions induced by thermal neutrons.

It is this feature of the liquid metal fuel reactor that makes the concept so attractive. Clearly the success of the nuclear energy industry depends on the ability of the industry to design and build power reactors that utilize the fertile materials Th and U-238 efficiently. We can see how a liquid metal fuel reactor fits into the picture by examining briefly the breeding problem.

There are two types of breeders that show promise. The first is a fast breeder and the second is the only possible thermal breeder which uses the U-233-Th fuel cycle. Although thermal breeding has not been demonstrated, there is today no question about its doing so.

In general the fuel in a thermal reactor is much more dilute than the fuel in a fast reactor. As a result a much higher power per gram of fuel and, hence, lower fuel inventory charge is possible with thermal reactors. Because of the high fuel density required in fast breeders, it seems unlikely that a fluid fuel concept can be applied. About half of the core in present fast reactor concepts is filled with high density uranium and structural material.

A concept of a liquid metal fuel breeder reactor has been developed at the Brookhaven National Laboratory. This reactor will produce 2000 psig–975 F steam for delivery to the turbine throttle. The turbo-generator plant utilizes this energy to produce 240,000 kw of which 226,000 kw is the net saleable electrical output. The reactor is a cylindrical vessel containing a graphite core drilled with holes through which the fuel solution flows. The core is surrounded by a breeder blanket region containing a slurry of Th_3Bi_5 suspended in molten bismuth, which is also circulated through a heat exchanger for cooling. In this particular concept an intermediate heat exchanger which transfers the heat from bismuth to sodium is used to minimize the inventory of expensive bismuth solution and to prevent the decomposition of steam by the gamma radiation from the fuel solution. The core and blanket region are separated by a high density impervious graphite core tank to minimize the loss of neutrons to structural materials within the reactor.

The breeder blanket will be a slurry of thorium bismuthide in bismuth because of the low solubility of thorium in liquid bismuth. However, since the density of a thorium-bismuthide particle is very nearly equal to that of the liquid bismuth, it is felt settling out problems will not be so severe.

"The Organic Moderated Reactor Experiment," presented by **C. A. Trilling,** North American Aviation, Inc., involves basically an organic moderated, reflected and cooled reactor which in the author's words, "is nothing but a pressurized water reactor in which the water has been replaced by a hydrocarbon. It is a PWR, but without the pressure." This statement needs some qualification since an organic reactor has to be pressurized to some extent, though practically an order of magnitude less than a pressurized water reactor.

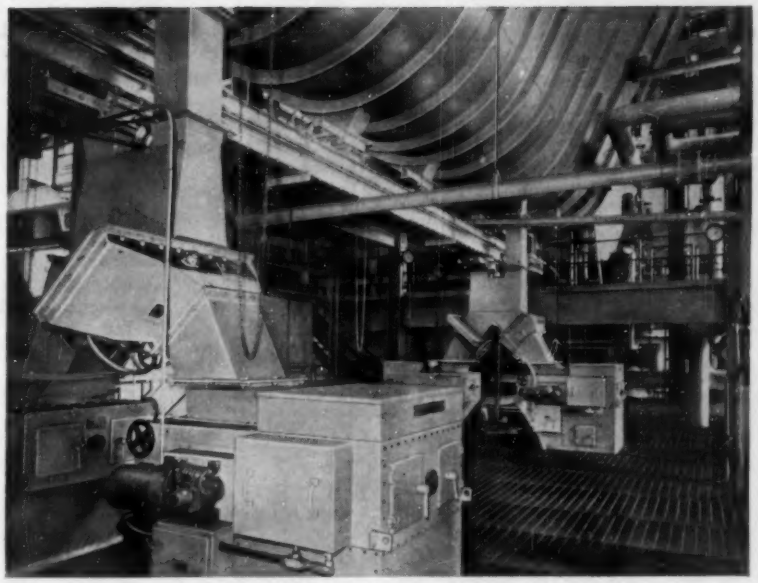
The fundamental advantage of an organic moderated reactor, as the author states, is its low operating pressure. Other major advantages are lack of corrosion effects upon standard materials of construction and extremely low activation upon exposure to neutrons as well as an absence of chemical reaction with uranium. With the possibility of using low pressure equipment, the absence of requirement for special alloys, and a need for only a minimum of shielding, an organic moderated reactor requires only a relatively modest capital investment for a land based power plant. Because of its low weight, it also constitutes an ideal type of reactor for a mobile power plant.

On the other side of the ledger, however, it must be noted that most hydrocarbons are unstable under exposure to heat and radiation, and that they are quite poor heat transfer media. These disadvantages make impossible to generate steam at temperatures and pressures used in modern power plant practice, and impose the necessity of continuous purification of the coolant during reactor operation.

Theodore Jarvis, Ford Instrument Company, chose as his subject "The Gas Turbine Reactor." Mr. Jarvis first presented certain important differences between the well-known British development of gas cooled reactors and the U. S. development. The British unit, the first Calder Hall reactor, appears to be a cross between a reactor experiment for gas cooled reactors and a dual purpose, plutonium-power plant.

Since the Calder Hall plant is large, the maximum operating pressure is limited by the maximum size pressure vessel which can be fabricated at the site. The Calder Hall pressure vessel is 2-inches thick welded steel plate about 40 feet in diameter and 60 feet high. The construction of this vessel is described as "providing a novel and interesting job,"—a description with which we would certainly concur.

The U. S. gas cooled reactor effort, by contrast, envisions machines all



$4,000,000 HEATING SYSTEM
depends on
RICHARDSON COAL SCALES

On 24-hour duty at McGuire Air Base, Wrightstown, New Jersey, four Richardson H-39 Coal Scales ... capable of handling up to 80 tons of coal per hour ... contribute their substantial part to providing heat for 75 key buildings in a huge new heating system.

And checking on coal consumption is a simple matter. Each scale has a capacity of 200 lbs. and, during operation, the total amount of coal weighed hour after hour is registered on a direct-connected counter. Hold-ups in flow of coal to the boiler are eliminated by a simple gravity-operated by-pass mechanism in the feeder. Added protection is provided in locating all electrical equipment outside the coal chamber, insuring completely fault-free performance.

This reliance on Richardson equipment in a vital function is repeated time and again in power installations throughout the country. Send for H-39 Coal Scale Bulletin #0352A for the reasons behind this confidence.

Richardson
MATERIALS HANDLING BY WEIGHT SINCE 1902

RICHARDSON SCALE COMPANY, Clifton, N. J.

Atlanta • Boston • Buffalo • Chicago • Cincinnati • Detroit • Houston • Memphis
Minneapolis • New York • Omaha • Philadelphia • Pittsburgh • San Francisco • Wichita
Montreal • Toronto • Havana • Mexico City • San Juan
Richardson Scales S.A., 1-3 Rue de Chantepoulet, Geneva, Switzerland
Richardson Scale Co. Ltd., 40-42 George Street, Nottingham, England

2356

operating at very high temperatures within a power output range of from 2- to 15-mw. Either closed cycle gas turbine machinery has been used, or gas is used as intermediate coolant transferring heat to an open or closed cycle power plant. The reactors have been small, ranging from 4 ft by 4 ft to 6 ft by 7 ft in size. Fuel enrichments from 10 per cent to around 90 per cent have been employed. Power densities and specific powers are quite high, comparing favorably with liquid metal or water cooled reactors. The most outstanding diference between the American effort and the British effort, however, is the one of status. The first British plant is in operation. The U. S. gas cooled reactor is only pencil and paper.

A number of preliminary conclusions are emerging from our work to date, which indicate that there are certain distinct advantages which the the gas cooled reactor possesses for this and possibly other maritime applications. Clearly, the use of solid fuel elements in a maritime reactor is most desirable from the point of view of safety. In the event of a collision at sea, such as recently occurred in the Atlantic, the rupture of liquid fuel carrying pipes would entail very serious consequences. The use of solid fuel elements would considerably minimize this risk. But the gas cooled reactor also had advantages from the viewpoint of efficiency. If fission product leakage can be controlled so that the turbo-machinery compartment need not be shielded, the pounds per shaft horsepower for this type of reactor are expected to be considerably lower than in others. In addition, the small amount of auxiliary equipment required for shut down cooling compares favorably with the auxiliary equipment for pressurized water and organic moderated reactors.

Willard S. Mott, Nuclear Development Corporation of America, gave the final paper of this session on "The Sodium Deuterium Reactor," one of the oldest concepts recently chosen for comprehensive testing for the Chugach Electric Association of Anchorage, Alaska. This paper discusses the advantages of this concept.

First, from the standpoint of all potential reactor users, is the fact that it can produce modern steam conditions without a pressure vessel in the reactor. This should not only result in an important cost saving in the pressure vessel, but should open the way for some interchangeability between fuel fired and nuclear steam generators. It would also appear to have some safety advantages.

The small size of the reactor together with the low enrichment make it attractive for small domestic applications. The projected use of natural uranium in larger sizes suits it for foreign nations without enrichment facilities, since D_2O is becoming a widely available commodity.

There is little unknown technology which must be incorporated in the concept. The major task is the combining of known technologies.

The low neutron temperature resulting from the cool moderator develops a higher conversion ratio, a better plutonium quality, and a built-in negative moderator temperature coefficient. The D_2O moderator also provides a high neutron source.

The reactor has a long neutron lifetime.

The moderator itself presents a number of advantages including the use of cold control thimbles to displace moderator, shim control by moderator height or temperature variation, the safety feature of moderator dumping without loss of cooling capacity, no necessity for separate canning, no stored energy, and no radiation damage.

It brings with it, however, a couple of disadvantages—namely, its cost and the necessity for special purity control.

EXTRA YEARS
OF MORE DEPENDABLE POWER
and at less cost per pound of steam

TODD BURNERS
GAS OR OIL
PRODUCTS DIVISION
TODD SHIPYARDS CORPORATION

HEADQUARTERS: Columbia & Halleck Streets, Brooklyn 31, N. Y.
PLANT: Green's Bayou, Houston 15, Texas

TODD NEW YORK, U.S.A.

ERNST
HIGH PRESSURE
GLASSES
and GASKETS
All sizes to fit your gages and valves

FIG. 22 SERIES 750

FIG. 21 LIP-MOLD

STATE YOUR REQUIREMENTS
All shipments from stock.
Send for Catalog
ERNST WATER COLUMN & GAGE CO.
Livingston 6-1400 LIVINGSTON, N. J.

Reactor Safety

At a special press round table sponsored by the Nuclear Energy Writers Association the subject of Reactor Safety was handled by **C. Rogers McCullough,** chairman, AEC Advisory Committee on Reactor Safeguards. Mr. McCullough outlined the technical aspects of the safety problem and then threw the meeting open for questions. As he pointed out, in this field, actual accident experience is very meager. Because we lack accident statistics and are still in the research and development phases of this field, we are not yet able to develop detailed rules and formulas of general applicability. Therefore, in dealing with hazards problems, we must apply the technical judgment to the individual circumstances of each case.

Under the conditions of the Atomic Energy Act of 1954, a necessary condition for a license for an atomic facility as defined by the Act is the assurance that the health and safety of the public will be adequately protected. The AEC Staff and the Advisory Committee on Reactor Safeguards work together reviewing reactor proposals and related facilities to make sure that this protection of the public health and safety is maintained. In the cases of reactors which are unusual, which have special problems or have a large power rating, the hazards matters are referred to the Advisory Committee on Reactor Safeguards for technical advice. This Committee studies the problem and makes appropriate recommendations to the Atomic Energy Commission.

The principal hazard which must be evaluated is the possible release, as a result of accident, of the highly toxic fission products which are contained in the reactor and the other radioactive by-products which may be generated during the reactor operation.

In evaluating the safety of a proposed reactor, it is necessary to analyze the transient problem, the afterheat problem and the problem of holding to a safe level the releases of by-product radioactive material during normal or somewhat abnormal operation.

A second paper, "Influence of the National Academy of Science's Report on the Nuclear Power Industry," presented in another session by **J. W. Healy,** General Electric Co., covered the biological effects of radiation and methods of achieving protection and, although widely circulated, is well worth reporting. In the case of waste disposal of radiation materials these points were made:

(1) The average exposure of the population's reproductive cells to radiation above the natural background should be limited to 10 roentgens from conception to age 30.

(2) The 10 roentgen limit should be reconsidered periodically with a view to keeping the reproductive cell exposure at the lowest practicable level.

(3) A national agency should control and keep records of all dumping of radioactive material in the ocean.

(4) An international body should set up safe standards for marine and air disposal of radioactive materials as soon as possible.

(5) Until advances in reactor technology substantially reduce potential hazards, buildings that house reactors located near populated areas should be sealed against the release of radioactive materials in the event of accident.

Further, the National Academy of Science Study produced these recommendations:

(1) Records should be kept for every individual, showing his total accumulated lifetime exposure to radiation.

(2) Individual persons should not receive a total accumulated dose to the reproductive cells of more than 50 roentgens up to age 30 years, and not more than 50 roentgens additional up to age 40.

(3) That every effort be made to assign individuals to tasks involving higher radiation exposures who, for age or other reasons, are unlikely thereafter to have additional offspring.

At times it pays to be blinded !

But certainly not when you analyze coal values. Before you contract or place an order for your coal supply, a comparative study of evaporative results should be made.

No coal is 100% efficient. But with a properly, uniformly sized coal you'll utilize a higher percentage of Btu content. This more efficient combustion means lower steam costs for you.

At our Enos and Enoco Mines . . .

specific gravity washing, exact sizing and mechanical size blending produce a coal free of loose impurities, tailored to your stoker requirements. Each shipment is guaranteed to be of the same uniform size-consist and high quality. You'll find that exactly sized, properly prepared Enos and Enoco coals reduce Btu waste.

Why not give us a call today? Let us *prove* that superior preparation of quality Enos and Enoco coals give you more efficient utilization of Btu content for lower steam cost.

Place a trial order.
Make a test comparison.

THE ENOS COAL MINING COMPANY

Sales Offices for Enos and Enoco Coals

1405 Merchants Bank Bldg. Indianapolis 4, Indiana
310 S. Michigan Ave. Chicago 4, Illinois

UNAFRAX
CONSTRUCTION COMPANY
1039 BROOKLINE BOULEVARD
PITTSBURGH 26, PA.

ANNOUNCES THE APPOINTMENT OF

MR. RICHARD F. WHALEY

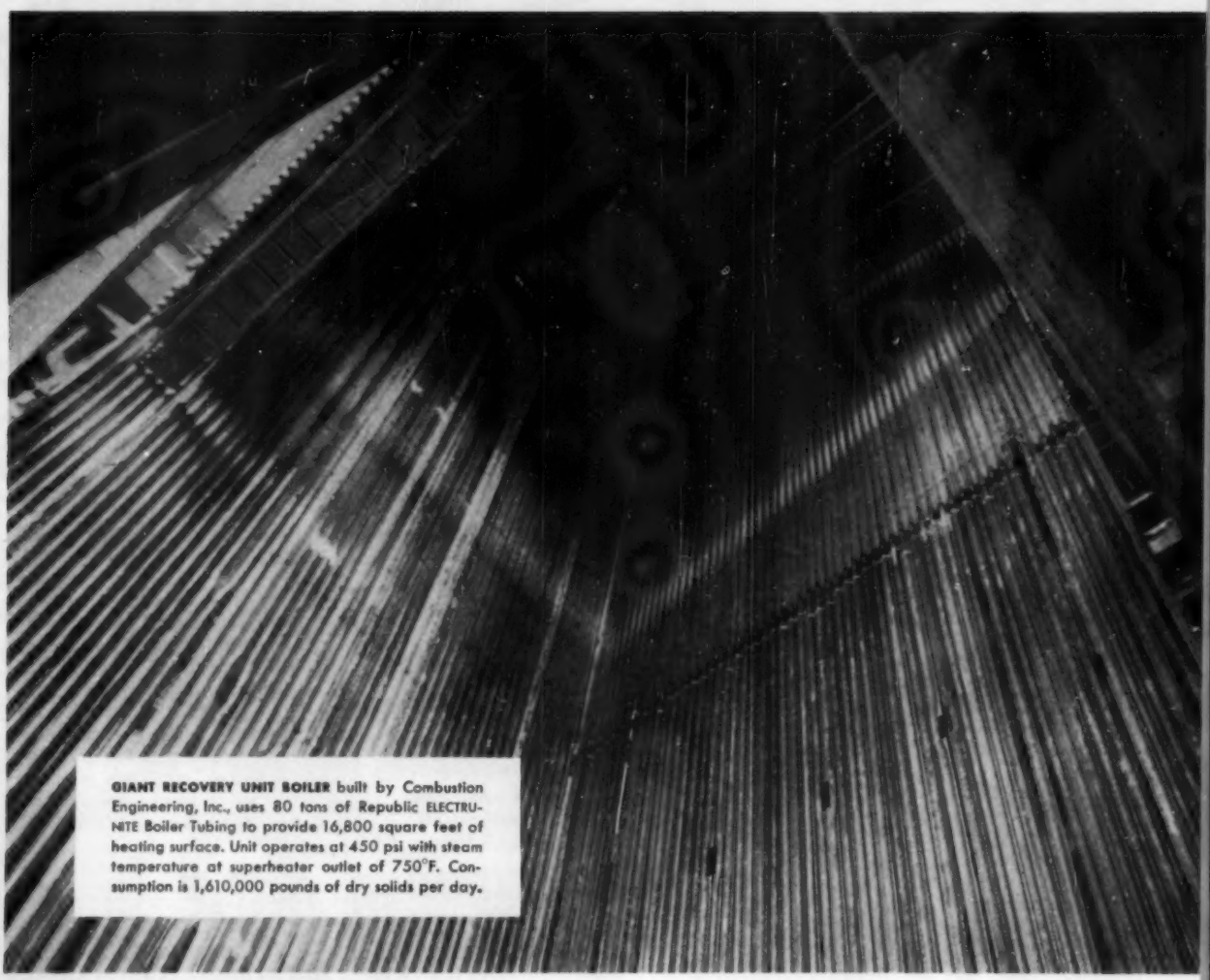
GENERAL SUPERINTENDENT OF CONSTRUCTION

(FORMERLY OF UNITED REFRACTORY CONSTRUCTION CO.)

HIS MANY YEARS EXPERIENCE INSTALLING REFRACTORY AND INSULATION ENCLOSURES FOR BOILERS ENABLES US TO ROUND OUT OUR ENGINEERING AND CONSTRUCTION SERVICES TO OUR CUSTOMERS AND FRIENDS.

LOcust 3-2431

Furnace Tubing for C-E Recovery in pulp mill is 100% REPUBLIC



GIANT RECOVERY UNIT BOILER built by Combustion Engineering, Inc., uses 80 tons of Republic ELECTRUNITE Boiler Tubing to provide 16,800 square feet of heating surface. Unit operates at 450 psi with steam temperature at superheater outlet of 750°F. Consumption is 1,610,000 pounds of dry solids per day.

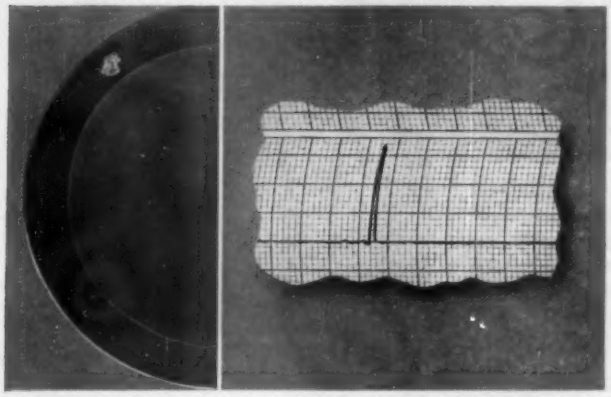
REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Unit ELECTRUNITE

UNIFORM DUCTILITY OF ELECTRUNITE Boiler Tubing helps rolling-in. Tube ends are easily and securely rolled into tube holes in drum. Result: consistently tight, weeper-free joints plus maximum ease of installation.



HERE'S THE ULTIMATE IN TUBE PROTECTION. FARROWTEST®, an electronic method of checking tubing for injurious defects, is exclusive with Republic. The oscillograph (shown above) records a defect registered on the macrograph. The presence of the defect passing through the FARROWTEST equipment automatically stops the machine, allowing the operator to mark and reject the tube. Send coupon for details.

Eighty tons, approximately 24,000 linear feet of Republic ELECTRUNITE® Boiler Tubing went into the boiler of one of the nation's largest C-E Recovery Units, recently installed for one of the South's largest pulp and paper plants.

Designed and built by Combustion Engineering, Inc., New York, the giant unit has a twofold purpose: to recover chemicals from spent liquor in the pulp mill; and to produce as much steam as possible from the boiler portion of the unit, using solids taken from the liquor as fuel. Since these functions are vital to both operation of the pulp mill and disposal of spent liquor, dependability and efficiency of the boiler are of paramount importance.

And that's where ELECTRUNITE excells.

ELECTRUNITE Boiler Tubes have a world-wide reputation for efficiency and reliability. The electric welding process, by nature, produces precise, uniform wall thickness assuring uniform, efficient heat transfer all around and throughout the length of each tube. Dependability cannot be threatened by longitudinal thin spots. Further, all ELECTRUNITE Tubes are hydrostatically or electrically tested to make certain of maximum performance in each length in any quantity.

Get all the facts on ELECTRUNITE Boiler, Condenser and Heat Exchanger Tubing from your local Republic Representative. Meantime, mail the coupon for your free copy of our handy wall chart entitled, "Care and Maintenance of Boiler Tubing." It's a handy guide to protecting your boiler installation from corrosion, erosion and physical wear and tear. Do it today.

REPUBLIC STEEL CORPORATION
Dept. C-1707
3172 East 45th Street, Cleveland 27, Ohio

Please send:
- ☐ Illustrated booklet giving facts on ELECTRUNITE Boiler Tubes
- ☐ 8-page brochure on Heat Exchanger Tubing—carbon steel ☐ stainless steel ☐
- ☐ Handy wall chart on Care and Maintenance of Boiler Tubes
- ☐ Data on exclusive FARROWTEST

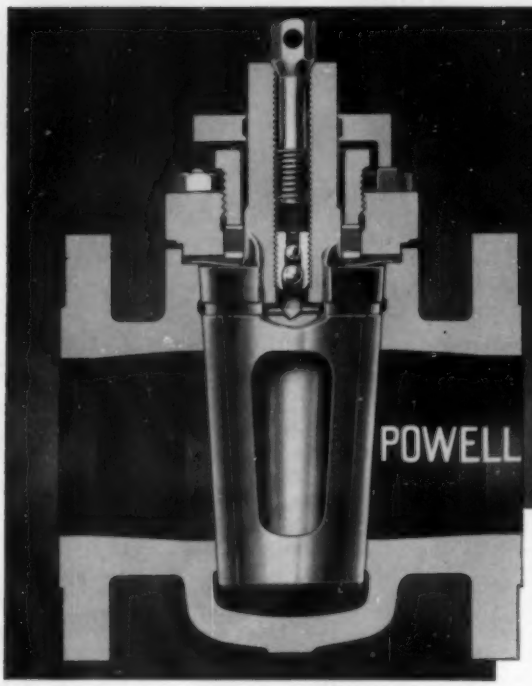
Name_____ Title_____
Firm _____
Address _____
City_____ Zone____ State_____

STEEL
and Steel Products

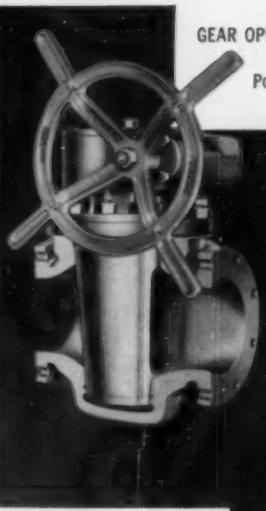
POWELL

Lubricated Plug

VALVES



GEAR OPERATED PLUG VALVE (Sectional). 6" and larger, Flanged Ends. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.



BOLTED GLAND TYPE. 6" to 12" 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel. May easily be converted to gear operation by removing stop collar and installing a packaged self-contained gear unit.

SCREWED GLAND TYPE (Sectional). 1" to 4", Flanged Ends. Wrench operated. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

Powell Lubricated Plug Valves maintain our 110-year tradition of quality and precision. Only the finest available materials are used. And painstaking quality control is rigidly enforced through each and every step of manufacture.

Features include quick and positive operation—just a quarter-turn to open or close. Lubricant grooves surrounding each port provide a positive seal when the valve is closed. In an open position, seating surfaces are not exposed.

Valve users who want one source of supply for lubricated plug as well as all types of bronze, iron, steel and corrosion-resistant valves will want full details on Powell Lubricated Plug Valves.

Available in Steel and Semi-Steel through distributors in principal cities. If none is located near you—or if you need help on valve problems—write direct to

PERFORMANCE
PV
VERIFIED

BRONZE, IRON, STEEL AND CORROSION-RESISTANT VALVES

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

The source of supply for all valve needs!

LOWER STOCKPILING COSTS

with versatile "EUC" Twin-Power Scraper

Loaded from river barges, the "Eucs" haul coal for immediate plant use and for stockpile storage.

Euclid "Twin" dumps its big load fast into drive-over hopper that supplies the plant.

A Midwest power company has added two of these overhung engine "Twins" to their fleet of other Euclid Scrapers. These new Model TS-18 "Eucs" provide even greater efficiency in coal reclaiming and stockpiling.

Public utilities and industrial plants have found the Euclid 4-wheel drive Twin-Power Scraper a real cost-cutter in coal stockpiling. The Twin-Power principle, pioneered by Euclid, enables this unit to load itself in loose or compacted coal. Movement of the standard 27.00 x 33 or optional 33.5 x 33 tires over the pile increases compaction 10 to 15 lbs. per cu. ft., eliminating spontaneous combustion problems.

The new overhung engine TS-18 provides even more maneuverability and economy than earlier Euclid "Twins" that had proved their advantage over other stockpiling equipment. It has two 218 h.p. engines, each driving a separate axle through a Torqmatic Drive. For jobs requiring even greater power, the tractor is available with a 300 h.p. engine. This new "Twin" can carry a 23-ton load at speeds up to 26 mph. With its exceptional maneuverability and ease of operation it works in close quarters extending, raising, and relocating stockpiles.

To get a production and cost estimate for your coal handling problems, call the Euclid dealer near you. He can show you why ***Euclids are your best investment.***

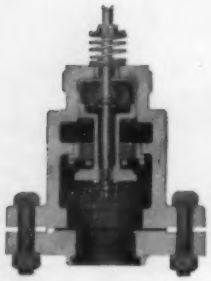
EUCLID DIVISION, GENERAL MOTORS CORPORATION, Cleveland 17, Ohio

Euclid Equipment

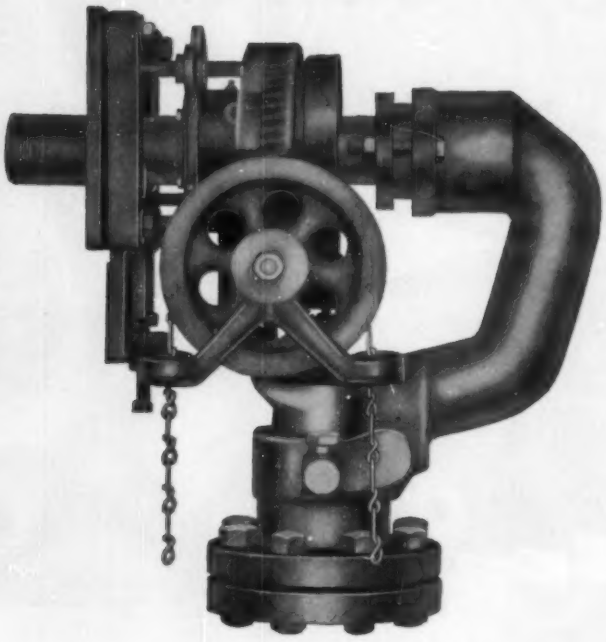
FOR MOVING EARTH, ROCK, COAL AND ORE

BAYER
STEPS UP BOILER PERFORMANCE

DISTINCTLY DIFFERENT



Bayer Balanced Valves are famous for their long life and continued tightness



Bayer Single Chain Balanced Valve Soot Cleaner

WITH THE Bayer Balanced Valve Soot Cleaner the balancing chamber above the piston disc impounds steam when the valve closes, thus relieving valve parts from shock. The valves remain *steam tight* because the dashpot action causes the valve to seat gently. Unbalanced valves close with a hammer stroke and soon become leaky.

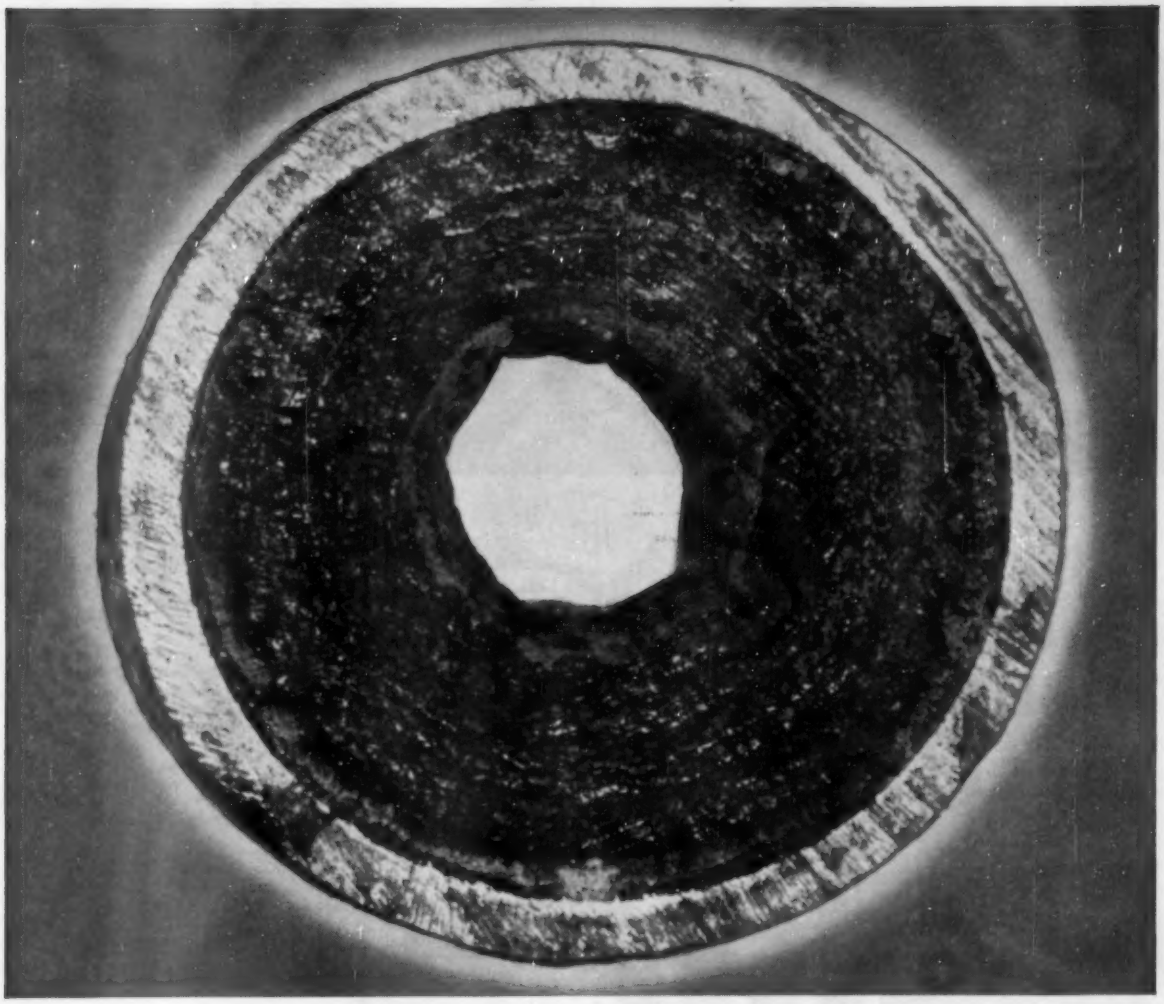
When stationary elements are used the Bayer stationary balanced valve head may be furnished. Thus all the cleaning elements of the entire soot cleaner system can be controlled by the Bayer quick-opening Balanced valves. This gives a uniform or standard valve controlled system and in addition, when high pressures require a reduction in pressure *at each individual element* this Balanced valve unit, whether used with a stationary or a revolving element, can be fitted with an integral orifice plate valve.

Piping connections can be kept in the same plane and undesirable bends or fittings avoided when the Bayer Balanced Valve is installed with both stationary and revolving elements.

Valve parts are standard and interchangeable and when high pressure heads are fitted with orifice plate regulating valves these parts are also interchangeable.

THE BAYER COMPANY

SAINT LOUIS, MISSOURI, U. S. A.



END OF THE LINE

SCALE—layer upon layer of it—has reduced the inside diameter of this pipe to practically nothing. It's a common occurrence in some power plants, and the results are costly. The line must be taken out of service. That means production loss and expensive maintenance or replacement.

Scale, sludge, carry-over, and return-line corrosion are but a few of the problems that must be overcome to assure efficiency in boiler plant operation. In Dearborn's complete line of water conditioning products, there is the correct treatment to eliminate every water trouble—the properly balanced treatment to reduce unnecessary maintenance, avoid shutdowns, and protect valuable equipment.

Since 1887, Dearborn products have provided trouble-free water to users of steam in all types of industry. That's why, today, power engineers in leading industrial plants throughout the nation look to Dearborn for consultation and assistance in solving their water treating problems.

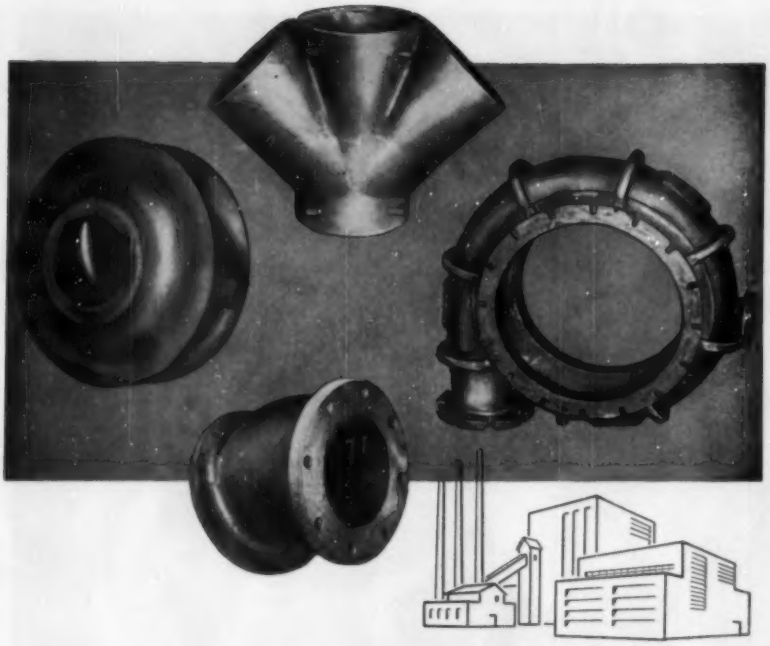
MAIL THE COUPON

Dearborn Chemical Company, Dept. COM
Merchandise Mart Plaza, Chicago 54, Ill.
Please send me complete information on Dearborn Water Conditioning.

Name.....*Title*.....
Company.....
Address.....
City.....*Zone*....*State*.....

Dearborn®

...a leader in water conditioning and corrosion control



"ABRASIVE WEAR SHARPLY REDUCED" WITH ABK METAL

For longer service in pump casings, pipes, fittings and other parts subject to abrasion, install castings of ABK Metal. A nickel-chrome iron of controlled structure, ABK Metal is produced only by American Brake Shoe Co.

Time after time, on installation after installation, reports show that ABK Metal is the most economical material for handling ash. The ultimate saving on replacement parts alone is appreciable. The saving in maintenance and shut-downs may be even higher.

Extended life of 4 or 5 to 1 is not unusual when ABK Metal replaces other iron castings—especially in those ash handling or disposal systems where the most severe type of abrasion is encountered. Don't let ABRASION steal your operating dollars . . . SPECIFY ABK METAL.

ABK METAL fights ABRASION

1533 AMERICAN Brake Shoe COMPANY

BRAKE SHOE AND CASTINGS DIVISION
230 Park Avenue, New York 17, N. Y.

Advertisers' Index

Aerotec Corporation, The..... *
Air Preheater Corporation, The 14
Allis-Chalmers Mfg. Company, Construction Machinery Div. 17
Allis-Chalmers Mfg Company, General Machinery Div..... *
American Blower Corporation. .....34 and 35
American Brake Shoe Company 82

Bailey Meter Company..... 16
Baltimore & Ohio Railroad.... 30
Barber-Colman Co., Wheelco Instruments Div..... *
C. O. Bartlett & Snow Company, The..... 31
Bayer Company, The..... 80
Bituminous Coal Institute.... 23
Blaw-Knox Company, Blaw-Knox Equipment Div..... *
Buell Engineering Company, Inc..... 38
Buffalo Forge Company....8 and 9

Carborundum Company, The. *
Chesapeake & Ohio Railway... 26
Clarage Fan Company..... 84
Combustion Engineering, Inc. .....Second Cover, 28 and 29
Combustion Publishing Company, Inc..... 56
Copes-Vulcan Div., Blaw-Knox Company.....4 and 5
Crane Company..... *

Dampney Company, The..... 72
Dearborn Chemical Company. 81
De Laval Steam Turbine Company..... 15
Diamond Power Specialty Corporation.....Third Cover
Dowell Incorporated..... 50

Eastern Gas & Fuel Associates. 6
Economy Pumps, Inc..... 68
Edward Valves, Inc..... *
Enos Coal Mining Company, The..... 75
Ernst Water Column & Gage Company.....74 and 75
Euclid Division, General Motors Corporation..... 79

Fairmont Coal Bureau..... *
Flexitallic Gasket Company... *
Foster Engineering Company.. *

General Electric Company.... .....20 and 21
General Refractories Company *
Gifford-Wood Company..... *
Graver Water Conditioning Company..... 25
Grinnell Company, Inc..... *

Hagan Corporation..... *
Hall Laboratories, Inc..... *
Haskins-Turner Company..... 56

(Continued on page 83)

Ingersoll-Rand Company. 12 and 13

Johns-Manville ..... 7 and 62

M. W. Kellogg Company, The. 22
Koppers Company, The 32

L. A. Water Softener Company 69
Leeds & Northrup Company .. *
Lukens Steel Company 18
Lummus Company, The ..... *

Manning, Maxwell & Moore, Inc. 11
W. K. Mitchell & Company 24

National Aluminate Corporation 2
National Exposition of Power & Mechanical Engineering 83
Norfolk and Western Railway. *

Pacific Pumps, Inc. ..... *
Peabody Engineering Corporation ..... *
Pennsylvania Crusher Div., Bath Iron Works Corp. 10
Pittsburgh Piping & Equipment Company ..... *
Powell Valves 78
Prat-Daniel Corporation ..... *

Refractory & Insulation Corporation 70
Reliance Gauge Column Company, The 71
Republic Flow Meters Company 33
Republic Steel Corporation .... 76 and 77
Research-Cottrell, Inc. ..... *
Rhopac, Inc. ..... *
Richardson Scale Company ... 73

Standard Tube Company, The 37
Stock Equipment Company ... 27
Sy-Co Corporation ..... *

W. A Taylor and Co ..... *
Thermix Corporation ..... *
Todd Shipyards Corp., Products Div. 74

Unafrax Construction Company 75

Walworth Company 36
Western Precipitation Corporation ..... Fourth Cover
Westinghouse Electric Corporation 3
Westinghouse Electric Corporation, Sturtevant Div. ..... *
C. H. Wheeler Manufacturing Company 68
Worthington Corporation ..... *

Yarnall-Waring Company 19

You've Got A Date In November at the

22nd NATIONAL EXPOSITION of POWER & MECHANICAL ENGINEERING

(Under auspices of ASME)

NOV. 26-30, 1956
In New York's New Coliseum

You and your key men have a date at one of the most important exhibitions of power progress anywhere, anytime. For many executives, production men and engineers, it will be the most profitable five days of the year. Every aspect of power—its production, its use, new techniques, new economies will be on view in hundreds of exhibits (including Atomic Energy) in the country's newest showplace—the Coliseum.

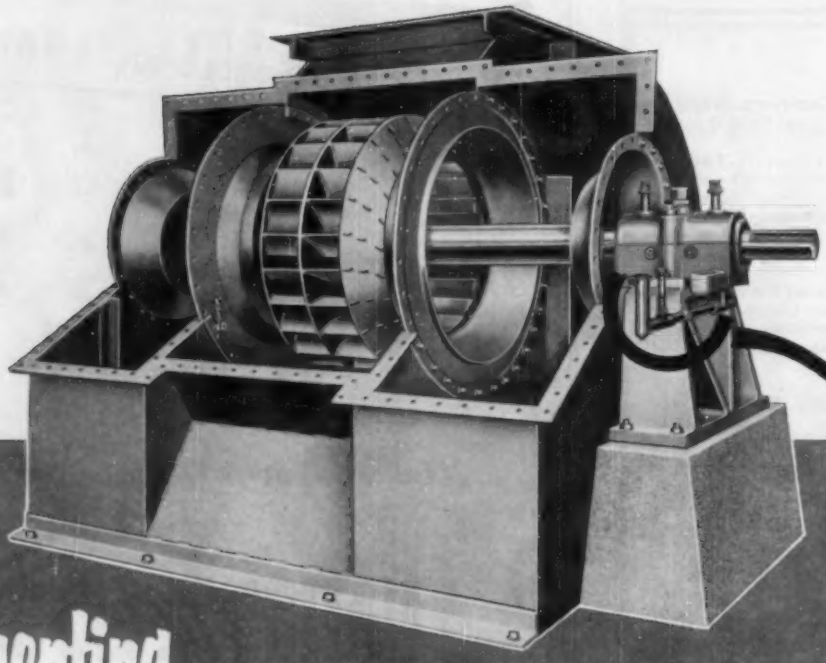
There is no more effective and profitable way of keeping up-to-date on what's new and different in the power field than to attend this exposition. And there is no more comfortable place to see it in than the new Coliseum.

Plan now and act now—write for advance registration for you and your key men to:

22ND NATIONAL EXPOSITION OF POWER & MECHANICAL ENGINEERING
480 Lexington Ave., New York 17, N. Y.

MANAGEMENT: INTERNATIONAL EXPOSITION COMPANY

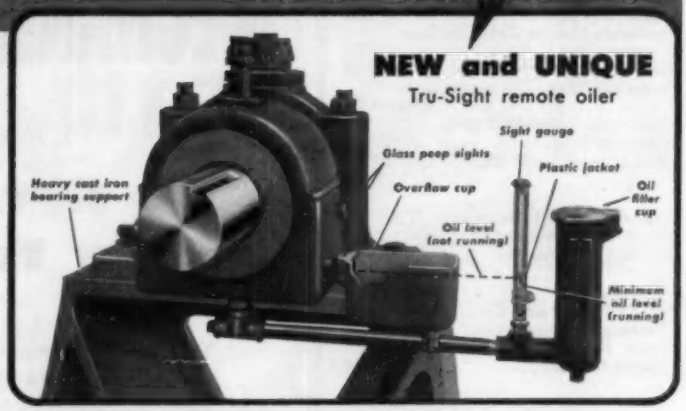
3509



Presenting... Another of the features distinguishing CLARAGE MECHANICAL DRAFT FANS

You get more than extra-heavy construction, extra-long service life from a Clarage Fan. You now get a vastly superior oiling arrangement for the bearings — as shown on the right.

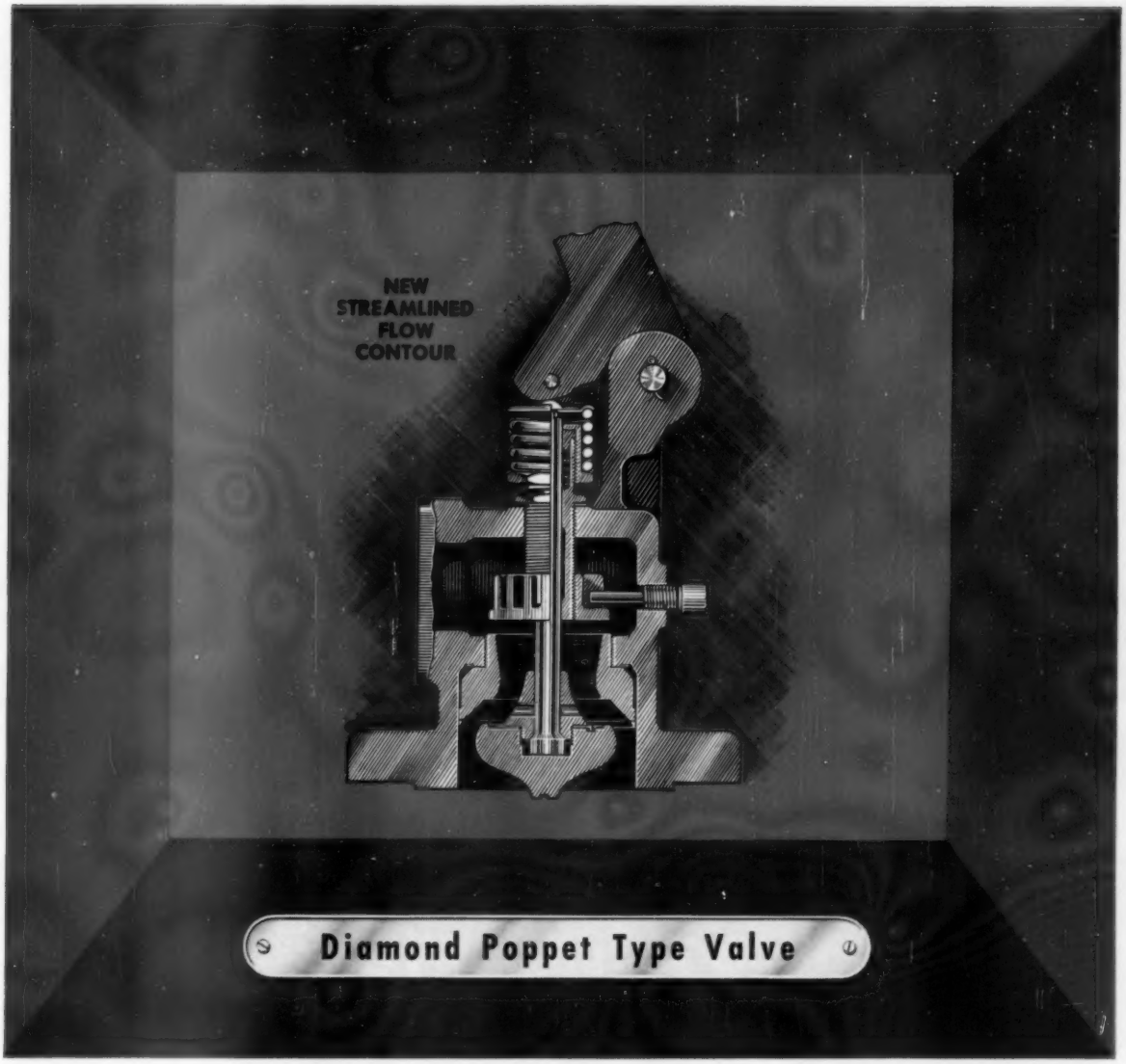
Send for Catalog 901-A describing the Clarage Type RT Fan and the many features that have made it the stand-out performer in forced and induced draft service. CLARAGE FAN COMPANY, Kalamazoo, Michigan.



Designed to simplify maintenance, this Clarage Oiler provides for accurate remote oil level indication when fan is running or not running . . . simplified oil level adjustment . . . quick filling . . . automatic overflow to prevent overfilling . . . cleanliness due to improved shaft seal effectiveness and use of overflow cup.

CLARAGE ... dependable equipment for making air your servant

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal



An Engineering Masterpiece

More than 300,000 Diamond Poppet Type Valves control the flow to Diamond Models G9B, IR and IK Blowers. Long experience has proved this design most satisfactory for such severe service. Diamond construction assures tight seating every time without close adjustments. Valve seat is welded in for high pressures, and Stellited seating surfaces are available. Integral adjustable pressure control (located outside the path of valve travel) does not interfere with full and immediate opening of the valve, thus avoiding wire drawing. Micrometer-like adjustment permits very close regulation at low flow rates. Throttling at the back seat eliminates this damaging action on the main seat. No line orifice is required. Mechanical action is direct without pilot or diaphragm actuation. Rugged stem, proper guiding and small packing surface result in minimum maintenance.

This engineering masterpiece is one of the important reasons for the superiority of Diamond Blowers.

7351

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO
Diamond Specialty Limited, Windsor, Ontario

New Automatic Precipitator Control by

WESTERN PRECIPITATION

offers many vital advantages...

1 LONG LIFE

This new control has indefinite life expectancy under all types of operating conditions. There are no tubes to replace, no high speed relays, counters, or timers to maintain. All circuitry consists of rugged "static" devices that have unusually long life!

2 RELIABILITY

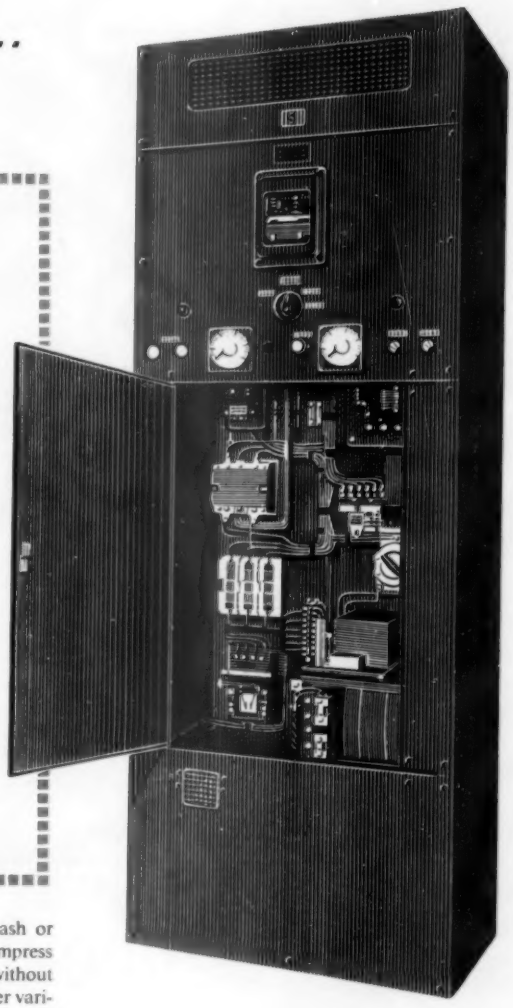
Optimum Precipitator power input is maintained regardless of operating conditions. The sensing control is simple, positive, accurate—and automatically evaluates the spark "Power Value" (intensity and frequency)—not just frequency or intensity alone.

3 STABILITY

Under short circuit, open circuit or other varying conditions, this control is completely stable and inherently trouble-free!

4 MODEST COST

Modest initial cost coupled with negligible maintenance assure optimum operating efficiency (therefore lower operating costs) throughout many years of continuous service.



WHEN using a Cottrell Precipitator for collecting dust, fume, fly ash or other suspensions from industrial gases, it is essential at all times to impress on the high voltage system the highest possible voltage and current without "flashover". Depending upon gas conditions, dust loading and other variable factors, the optimum voltage and current requirements vary widely from one minute to the next. Therefore, the vital importance of a simple, trouble-free and highly sensitive Precipitator Control is self-evident.

This new Western Precipitation Automatic Precipitator Control—*a product of the organization that has consistently led in the application of Cottrell Precipitators for industrial gas cleaning*—combines vital advantages found in no other competitive equipment. Our nearest representative will be glad to supply complete details. Or write direct!

Why not modernize your present out-dated Precipitator installation? The Western Precipitation Automatic Precipitator Control can be installed on any Cottrell unit. For further information contact our nearest office!

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases ..and Equipment for the Process Industries

Main Offices: **1022 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA**

Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

Representatives in all principal cities

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors